FLORIDA GEOLOGICAL SURVEY

TENTH AND ELEVENTH ANNUAL REPORTS

FLORIDA STATE GEOLOGICAL SURVEY

E. H. SELLARDS, PH. D., STATE GEOLOGIST

TENTH AND ELEVENTH ANNUAL REPORTS.

PUBLISHED FOR
THE STATE GEOLOGICAL SURVEY
TALLAHASSEE, 1918.

LETTER OF TRANSMITTAL.

To His Excellency, Hon. Sidney J. Catts, Governor of Florida:

SIR: In accordance with the Survey law I submit herewith my Tenth and Eleventh Annual Reports as State Geologist of Florida. The reports contain the statement of expenditures by the Survey for the year ending June 30, 1917, and for the year ending June 30, 1918, together with those investigations by the Survey that have progressed far enough to be available for publication. The two reports are included in one volume since by so doing there is a reduction in the relative cost of printing and binding.

Very respectfully,

E. H. SELLARDS,

State Geologist.

THE E O PAINTER PRINTING CO. DE LAND, FLA. Nº 12518

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TENTH ANNUAL ADMINISTRATIVE REPORT.

EXPENDITURES OF THE GEOLOGICAL SURVEY FOR THE YEAR ENDING JUNE 30, 1917, AND FOR THE YEAR ENDING JUNE 30, 1918.

The total appropriation for the State Geological Survey is $7,500 per annum. No part of this fund is handled direct by the State Geologist, as all survey accounts are paid upon warrants drawn upon the Treasurer by the Comptroller as per itemized statements approved by the Governor. The original of all bills and the itemized statements of all expense accounts are on file in the office of the Comptroller. Duplicate copies of the same are on file in the office of the State Geologist. The warrants when paid are on file in the office of the State Treasurer.

LIST OF WARRANTS ISSUED DURING THE YEAR ENDING JUNE 30, 1917.

JULY, 1916.	
E. H. Sellards, expenses, July, 1916	$ 78.50
Herman Gunter, assistant, expenses, July, 1916	19.37
Charles Scribner's Sons, publications	4.50
University of Chicago Press, subscription	3.60
G. P. Putnam's Sons, supplies	2.46
H. & W. B. Drew Company, supplies	11.74
Groover-Stewart Drug Company, supplies	4.00
Maurice Joyce Engraving Company, supplies	43.58
Yaeger-Rhodes Hardware Company, supplies	4.75
Alex McDougall, postage and box rent	27.00
Southern Express Company	12.06
AUGUST, 1916.	
E. H. Sellards, expenses, August, 1916	43.84
Milton-Bradley Company, supplies	1.51
Miss W. Wellborn, services	3.18
Southern Express Company	10.03
SEPTEMBER, 1916.	
E. H. Sellards, State Geologist, salary for quarter ending September 30, 1916	625.00
E. H. Sellards, expenses, September, 1916	76.88

Herman Gunter, assistant, salary for quarter ending September 30, 1916	375.00
Laura Smith, services	142.00
Ed Lomas, janitor services	30.00
E. O. Painter Printing Company	187.05
Maurice Joyce Engraving Company, engravings	157.62

OCTOBER, 1916.

E. H. Sellards, expenses, October, 1916	71.03
Herman Gunter, assistant, expenses, October, 1916	61.79
Charles Scribner's Sons, publications	13.50
H. & W. B. Drew Company, supplies	1.64
Maurice Joyce Engraving Company, engravings	49.91
Wrigley Engraving Company, engravings	1.30
Dr. O. P. Hay, services	50.00
Sydney Prentice, drawings	14.50
Erwin S. Christman, drawings	10.00
J. Thomas Stewart, varnishing floors	16.00
S. A. L. Railway, freight	26.84
Dan Allen, drayage	1.50
E. O. Painter Printing Company	884.37
The Letter Shop, supplies	2.22
G. I. Davis, postage	72.48
Southern Express Company	8.68

NOVEMBER, 1916.

E. H. Sellards, expenses, November, 1916	24.15
Charles Williams, supplies	14.74
T. J. Appleyard, State Printer	31.00
E. G. Chesley, Jr., Furniture Company, supplies	4.75
D. R. Cox Furniture Company, supplies	104.00
G. I. Davis, postage	75.00

DECEMBER, 1916.

E. H. Sellards, State Geologist, salary for quarter ending December 31, 1916	625.00
E. H. Sellards, expenses, December, 1916	111.50
Herman Gunter, assistant, salary for quarter ending December 31, 1916	375.00
Herman Gunter, assistant, expenses, December, 1916	58.80
Laura Smith, services	138.00
Ed Lomas, janitor services	30.00
T. J. Appleyard, State Printer, supplies	10.50
Abercrombie & Fitch Company, supplies	7.25
American Journal of Science, subscription	6.00
H. & W. B. Drew Company, supplies	4.83

G. I. Davis, postage	87.73
Southern Express Company	17.98

JANUARY, 1917.

E. H. Sellards, expenses, January, 1917	30.05
D. R. Cox Furniture Company, supplies	2.00
G. I. Davis, postage	10.00

FEBRUARY, 1917.

E. H. Sellards, expenses, February, 1917	89.64
Yaeger-Rhodes Hardware Company, supplies	5.40
G. I. Davis, postage	25.00
Southern Express Company	10.44

MARCH, 1917.

E. H. Sellards, State Geologist, salary for quarter ending March 31, 1917	625.00
E. H. Sellards, expenses, March, 1917	48.10
Herman Gunter, assistant, salary for quarter ending March 31, 1917	375.00
Laura Smith, services	122.00
Ed Lomas, janitor services	30.00
Southern Express Company	6.23

MAY, 1917.

Economic Geology Publishing Company, subscription	3.00
University of Chicago Press, subscription	3.60

JUNE, 1917.

E. H. Sellards, State Geologist, salary for quarter ending June 30, 1917	625.00
E. H. Sellards, expenses, May-June, 1917	27.68
Herman Gunter, assistant, salary for quarter ending June 30, 1917	375.00
Herman Gunter, assistant, expenses, June, 1917	40.95
Laura Smith, services	86.00
Ed Lomas, janitor services	30.00

Total expenditures for the year ending June 30, 1917	$7,445.75
Overcharge for year ending June 30, 1916	177.95
	$7,623.70
Appropriation for the year	7,500.00
Overcharge	$ 123.70

PUBLICATIONS ISSUED BY THE STATE GEOLOGICAL SURVEY.

The following is a list of the publications issued by the State Geological Survey since its organization:

First Annual Report, 1908, 114 pp., 6 pls.
Second Annual Report, 1909, 299 pp., 5 text figures, and one map.
Third Annual Report, 1910, 397 pp., 28 pls., 30 text figures.
Fourth Annual Report, 1912, 175 pp., 16 pls., 15 text figures, one map.
Fifth Annual Report, 1913, 306 pp., 14 pls., 17 text figures, two maps.
Sixth Annual Report, 1914, 451 pp., 90 figures, one map.
Seventh Annual Report, 1915, 342 pp., 80 figures, four maps.
Eighth Annual Report, 1916, 168 pp., 31 pls., 14 text figures.
Ninth Annual Report, 1917, 151 pp., 8 pls., 13 text figures, two maps.
Tenth and Eleventh Annual Reports (this volume), 1918.
Bulletin No. 1. The Underground Water Supply of Central Florida, 1908, 103 pp., 6 pls., 6 text figures.
Bulletin No. 2. Roads and Road Materials of Florida, 1911, 31 pp., 4 pls.
Press Bull. No. 1. The Extinct Land Animals of Florida, February 6, 1913.
Press Bull. No. 2. Production of Phosphate Rock in Florida during 1912, March 12, 1913.
Press Bull. No. 3. Summary of Papers Presented by the State Geologist at the Atlanta Meeting of the American Association for the Advancement of Science, December 31, 1913.
Press Bull. No. 4. The Utility of Well Records, January 15, 1914.
Press Bull. No. 5. Production of Phosphate Rock in Florida during 1913, May 20, 1914.
Press Bull. No. 6. The Value to Science of the Fossil Animal Remains Found Imbedded in the Earth, January, 1915.
Press Bull. No. 7. Report on Clay Tests for Paving Brick, April, 1915.
Press Bull. No. 8. The Phosphate Industry of Florida during 1917, May 2, 1918.
Press Bull. No. 9. Survey of Mineral Resources, May 10, 1918.

DISTRIBUTION OF REPORTS.

The reports issued by the State Geological Survey are distributed upon request, and may be obtained without cost by addressing the State Geologist, Tallahassee, Florida. Requests by those living outside of the State of Florida should be accompained by postage or if desired the reports will be sent express collect.

GEOLOGY BETWEEN THE APALACHICOLA AND OCKLOCKNEE RIVERS IN FLORIDA.

BY E. H. SELLARDS AND H. GUNTER.

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GEOLOGY BETWEEN THE APALACHICOLA AND OCKLOCKNEE RIVERS IN FLORIDA.

E. H. SELLARDS AND H. GUNTER.*

LOCATION, AREA AND MINERAL INDUSTRIES.

H. GUNTER.

The area to which this report relates embraces the three counties of Gadsden, Liberty and Franklin lying between the Ocklocknee and Apalachicola rivers and extending from the Florida-Georgia state line to the Gulf of Mexico. The area of Gadsden county is approximately 500 square miles, or 320,000 acres; that of Liberty, 725 square miles, or 464,000 acres; and that of Franklin, 731 square miles, or 467,240 acres, making a total area of 1,956 square miles, or 1,251,240 acres.

Gadsden county is one of the leading agricultural counties of the State. In 1903 the Bureau of Soils of the U. S. Department of Agriculture made a soil survey of this county and accompanying this report was a map indicating the different soils and their location. The results of this survey show that the soils of this county are well adapted to the growing of a great diversity of staple farm products. The production of the shade-grown leaf tobacco for cigar wrapper purposes is of first commercial importance, while sugar cane, corn, sweet potatoes and peanuts rank next and are grown on a large scale.

The interior of the county, except where cut into by streams, forms a plateau, the top of which lies from 250 to a little more than 300 feet above sea. Numerous clear-water streams are found in this county, which afford irrigation and some water power. These streams cut very deeply, particularly those in the western portion of the county, tributary to the Apalachicola river, causing a very broken and rugged topography.

Liberty county has many streams, and those tributary to the Apalachicola river cut across the bluff and into the plateau mak-

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* The field work on this report has been done jointly by the authors. The text has been prepared as indicated under the authors' names.

ing the topography very broken and resulting in a great diversity of surface features. Some of the streams head in a very characteristic manner forming what are locally termed "steepheads." In the eastern and southern portions of the county the hills give way to very gradual slopes which continue through to the Ocklocknee river, the eastern boundary of the county, and through the county southward into Franklin county.

The favorable location of Franklin county on the Gulf of Mexico invited very early settlement and development. The Apalachicola river which heads in North Georgia, makes its way through the fertile red hills of that State and through some of the best lands of Florida finally discharging its waters into the Gulf of Mexico at Apalachicola. Before the building and development of the railroads this river was the principal medium of transportation and Apalachicola was the main point of export as well as import for a large territory, not only for Florida but for adjoining states.

The very gentle sandy slope extending from the north merges in this county into flatwoods, bays and swamps. In 1915 a soil survey was made of Franklin county by the Bureau of Soils of the U. S. Department of Agriculture, accompanying which is a map showing different types of soils, their location and extent, as well as the different streams, bays, swamps and other natural features. The soils within this area are all sandy, the predominating type being that described in the soil report as the "hyde fine sand." But little attention as yet has been given to agriculture, the chief industries of the county being lumbering, turpentining, the catching and shipping fish, oysters and shrimp. The canning of oysters and shrimp is rapidly increasing and is one of the leading industries of the county.

CLIMATE.

Records on temperature and rainfall are available at the Tallahassee Station and at the Apalachicola Station from the United States Weather Bureau. These stations may probably be accepted as fairly representative of the area covered by this report. The average for rainfall and temperature at Tallahassee are based on records from 1891 to 1903.* The average for rainfall and tem-

* Climatology of the United States, by Alfred Judson Henry, Bull. Q, U. S. Dept. Agriculture.

perature at Apalachicola are based on records as contained in the report on the soils of Franklin county by the Bureau of Soils, U. S. Department of Agriculture.*

The annual mean temperature at Tallahassee, in Leon county, is 67 degrees Fahrenheit. The mean for the four seasons of the year is as follows: Winter, 53; Spring, 67; Summer, 80; Fall, 68. The absolute maximum summer heat recorded at this station is 97 degrees F. The minimum winter temperature recorded is 12 degrees F.

The annual mean rainfall at Tallahassee is 58.2 inches. This is distributed throughout the year as follows: January, 3.5 inches; February, 4.8 inches; March, 5.9 inches; April, 2.7 inches; May, 3.6 inches; June, 6.8 inches; July, 8 inches; August, 7.1 inches; September, 5.1 inches; October, 3.7 inches; November, 2.9 inches; December, 4.1 inches.

The annual mean temperature at Apalachicola, in Franklin county, is 69 degrees Fahrenheit. The mean for the four seasons of the year is as follows: Winter, 55; Spring, 69; Summer, 81; Fall, 71. The absolute maximum summer heat recorded at this station is 100 degrees F. The minimum temperature recorded is 20 degrees F.

The annual mean rainfall at Apalachicola is 56.1 inches. This is distributed throughout the year as follows: January, 4.1 inches; February, 2.3 inches; March, 2 inches; April, 2.8 inches; May, 4.9 inches; June, 3.3 inches; July, 6.7 inches; August, 9.3 inches; September, 10 inches; October, 2.8 inches; November, 2.6 inches; December, 5.3 inches.

VEGETATION.

The prevailing type of vegetation for this area as a whole is the open forests of long-leaf pine. In the more sandy and better drained areas of the long-leaf pine forests there is usually an undergrowth of black-jack oaks and other deciduous trees. However, this area may be broadly separated into three divisions: The rolling uplands of the northern part; the belt of long-leaf pine forests, and the alluvial swamp vegetation along the Apalachicola river.

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* Soil survey of Franklin County, Florida, p. 8, U. S. Department of Agriculture, Advance Sheet, Field Operations of the Bureau of Soils, 1915.

The rolling uplands of the northern part of this area, although largely cleared at the present time, supported originally a mixed timber growth, including short and long-leaf pine and many hardwood trees such as oak, hickory, dog-wood and magnolia. On the more level and sandy lands the chief timber growth is the long-leaf pine with more or less undergrowth of shrubby deciduous trees. Bordering the Apalachicola river are the alluvial swamps with a dense growth of hardwood deciduous trees conspicuous among which are the magnolia, beech, various oaks, ash, dog-wood, cottonwood and hickory. In the ravines and bluffs along the river the short-leaf pine grows in abundance. Likewise along these river bluffs and in the ravines two trees worthy of special mention, since so far as known they do not occur outside of Florida and only in this particular section of the State, are the two representatives of the yew family, *Tumion taxifolium* and *Taxus floridana*. These are two very rare and beautiful conifers, the latter, however, being the rarer of the two.

A detailed study of the vegetation of this area was made by Dr. R. M. Harper, and the results were incorporated in his report on the Geography and Vegetation of Northern Florida published in the Sixth Annual Report of this Survey. Five vegetation types were indicated for this area and the plants characterizing each type are there listed.

ELEVATIONS.

The only precise levels available in this area are bench marks established by the U. S. Coast and Geodetic Survey and by the U. S. Army Engineers. These are placed at intervals across the area from east to west following the line of the Seaboard Air Line railway and the Louisville and Nashville railroad, and in a northwest-southeast direction following the line of the Georgia, Florida and Alabama Railway. In addition to these precise levels the profiles and levels of some of the railroads have been available in determining elevations. The profile of the Apalachicola Northern railroad particularly has been of much service in the geologic study of this region. A copy of this profile on a reduced scale will be found on the map of this area accompanying this report. All the levels obtained have been of material assistance in the study of the topography and geology, and the writers wish to express

their appreciation of the assistance thus received from these various sources, which has very much facilitated the preparation of this report.

DESCRIPTION OF BENCH MARKS.

Midway, about 50 meters west of the Seaboard Air Line Railway station, 8 meters south of the main track. Elevation, 196.758 feet.

About 4 miles west of Midway, 100 meters west of mile post 181, 8 meters south of the Seaboard Air Line Railway track, level with the top of the rail, just east of a high railway embankment. Elevation, 122.395 feet.

About 3 miles east of Quincy, 100 meters west of mile post 186, 8 meters south of the Seaboard Air Line Railway track, 300 meters east of an overhead road crossing. Elevation, 218.182 feet.

Quincy, about opposite the east end of the Seaboard Air Line Railway station, 15 meters south of the main track. Elevation, 243.054 feet.

About 4 miles west of Quincy, 500 meters west of mile post 193, near road crossing, 8 meters south of Seaboard Air Line Railway track. Elevation, 275.941 feet.

Mount Pleasant, 30 meters southwest of the Seaboard Air Line Railway station, 8 meters south of the railroad track nearly opposite the U. S. mail stand. Elevation, 296.049 feet.

About 3 miles west of Mount Pleasant, 40 meters west of mile post 201, 8 meters south of the Seaboard Air Line Railway track. Elevation, 185.800 feet.

River Junction, 400 meters east of the Union Passenger station, bench mark is the highest point of the bolt in the northwest pillar of the railway water tank. It is 2 meters south of the main track. Marked U. S. B. M. Elevation, 76.096 feet.

River Junction, opposite the three-story brick building, 300 meters northeast of the Union Passenger station. Bench mark is the highest point of a railroad rail (projecting 2½ feet) acting as a guard at the corner of sidewalk. Elevation, 75.932 feet.

River Junction, about 350 meters west of the Union Passenger station, 100 meters west of the west end of the Seaboard Air Line and Atlantic Coast Line Railroad freight house, 30 meters south of the main track. Elevation, 79.577 feet.

About 2 miles west of River Junction, 65 meters west of west concrete pier of Louisville and Nashville Railroad bridge over the Apalachicola River, 1 meter north of trestle, bench mark is the top of a copper bolt set in a concrete post. Elevation, 63.786 feet.

About 2 miles west of River Junction in the triangle formed by three blazed trees; one of which is a 20-inch white oak, distant 20 feet; another is a 24-inch post oak, distant 100 feet; and the other is a 10-inch walnut, distant 127 feet. The bench mark is a copper bolt in a concrete post, 100 meters southwest of the west concrete pier at the west end of the Louisville and Nashville Railroad bridge over the Apalachicola River, and about 3 meters from the bank of the river. Elevation, 64.062 feet.

About 3.7 miles southeast of Havana at mile post 63, 10 meters north of Georgia, Florida and Alabama Railway track. Elevation, 143.871 feet.

Havana, about 100 meters west of the Georgia, Florida and Alabama Railway station, 2 meters from north fence of a tobacco field, 15 meters south of the Georgia, Florida and Alabama Railway main track. Elevation, 247.050 feet.

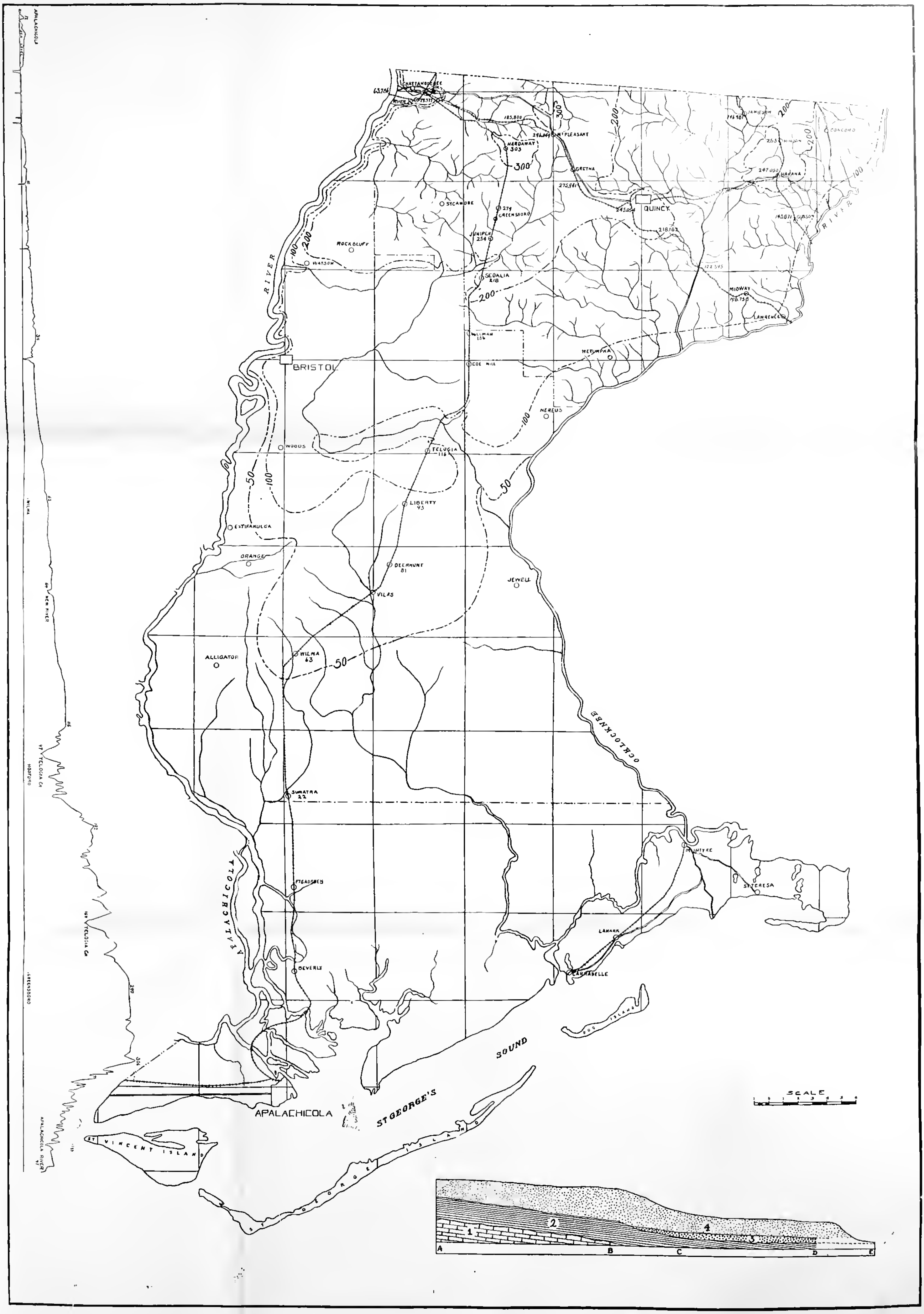
Jamieson, at the west end of the Georgia, Florida and Alabama Railway station platform, 2 meters south from the main track. Elevation, 146.981 feet.

ELEVATIONS AT RAILWAY STATIONS.

For convenience of reference the following list of elevations at railway stations has been compiled. The authority in each instance is given in the table. In addition to these elevations there is included on the map a profile across this area from north to south following the line of the Apalachicola Northern railroad from the Apalachicola river at River Junction to the Gulf at Apalachicola. This profile crosses the plateau at Hardaway, where the elevation is about 303 feet. On the map is shown the approximate location of the 100, 200 and 300-foot contours. (Map and profile inserted following page 16.)

LIST OF ELEVATIONS AT RAILWAY STATIONS IN GADSDEN, LIBERTY AND FRANKLIN COUNTIES.

Locality.	Authority	Elevation above sea (feet)
Altschule	G. F. & A. Ry.	209
Apalachicola	A. N. R. R.	5
Beverly	A. N. R. R.	10
Causey	A. N. R. R.	113
Coline	A. N. R. R.	26
Collins	A. N. R. R.	158
Criglar	A. N. R. R.	54
Deerhunt	A. N. R. R.	82
Eddy	A. N. R. R.	200
Florence	G. F. & A. Ry.	145
Fort Gadsden	A. N. R. R.	20
Franklin	A. N. R. R.	8
Greensboro	A. N. R. R.	280
Gretna	S. A. L. Ry.	294
Hardaway	A. N. R. R.	303
Havana	U. S. C. & G. S.	247
Hinson	G. F. & A. Ry.	253
Hosford	A. N. R. R.	88



MAP OF AREA BETWEEN THE APALACHICOLA AND OCKLOCKNEE RIVERS IN FLORIDA.

Scale of map: 1 inch equals 4 miles. Approximate location of the 50, 100, 200, and 300 foot contours is indicated by dotted lines. Elevations are given on the Seaboard Air Line, the Georgia, Florida and Alabama, and the Apalachicola-Northern railways. Exact levels based on established bench marks are indicated to the fraction of a foot, while approximate elevations are given in whole numbers.

At the side of the map is shown a profile following the Apalachicola-Northern railway from sea level at Apalachicola to River Junction near the State line. Scale of profile: Horizontal, 1 inch equals 4 miles; vertical, 1 inch equals 163 feet.

The sketch inserted on the map represents the section exposed on the Apalachicola river from the State line to Estifanulga. A, State line; B, Rock Bluff; C, Alum Bluff; D, Johnson's place; E, Estifanulga. No. 1, the Chattahoochee formation, which passes below water level in the river somewhat below Rock Bluff, No. 2, Alum Bluff formation, a part of which probably lies above water level in the river as far down stream as Estifanulga; No. 3, the Choctawhatchee formation, which rests on the eroded top surface of the Alum Bluff formation, and probably does not extend inland as far as Rock Bluff; No. 4, chiefly red sands and clays overlying the Choctawhatchee and Alum Bluff formations. Scale: Horizontal, 1 inch equals 4 miles; vertical, 1 inch equals 225 feet.

Jamieson	U. S. C. & G. S.	146
Juniper	A. N. R. R.	254
Leitman	G. F. & A. Ry.	149
Liberty	A. N. R. R.	94
Midway	S. A. L. Ry.	201
Millman	A. N. R. R.	186
Mount Pleasant	S. A. L. Ry.	301
Quincy	U. S. C. & G. S.	243
River Junction	Fla. Geol. Surv.	78
Sedalia	A. N. R. R.	218
Sumatra	A. N. R. R.	22
Telogia	A. N. R. R.	116
Telogia Creek, south crossing of A. N. R. R.	A. N. R. R.	45
Telogia Creek, north crossing of A. N. R. R.	A. N. R. R.	165
Wilma	A. N. R. R.	62
Zion	A. N. R. R.	75

MINERAL INDUSTRIES.

BRICK-MAKING CLAYS.

A good quality of common building brick is made from the clay in this area. Two brick-making plants, the Ocklocknee Brick Company and the Tallahassee Pressed Brick Company, are located in the eastern part of Gadsden county, the former on the Georgia, Florida and Alabama railway, the latter on the Seaboard Air Line railway. Both plants are near the Ocklocknee river and use a clay taken from the river valley.

FULLERS EARTH.

Fullers earth was first discovered in Florida near Quincy, Gadsden county, in 1893.* The industry has steadily grown until at the present time the largest and best equipped plants in the country are located in this county, which is the leading county of Florida in the production of this clay. According to statistics, Florida produces approximately three-fourths of the fullers earth of the United States, and of this amount Gadsden county produces more than half.

The Floridin Company, with mines at Quincy and at Jamieson, operates two of the largest and best equipped mines and plants in

*U. S. Geol. Surv., Min. Res. of the U. S. for 1914, Pt. II, p. 36, 1915.

the United States. A few years ago, during 1915, the plant at Quincy was destroyed by fire, but it has since been rebuilt on an enlarged scale. The Fullers Earth Company, with mines and mill at Midway, operates a modern plant which produces a large amount of the fullers earth coming from this county.

Acknowledgment should here be made of the courtesies extended to the Geological Survey by the management of the mines, Mr. W. L. McGowan of the Floridin Company and Mr. C. C. Ruprecht of the Fullers Earth Company, and for their help and kindly interest in the problem of the occurrence and age of the deposits which they are working. It is chiefly by the fossil animal and plant remains found within a formation that the age of that deposit can be determined. That this is appreciated by the management of the mines in this county is evidenced from the fact that upon different occasions fossils have either been brought in in person or sent to the Survey office. Furthermore, notice of the finding of fossils has been given so that observations and study might be made on the ground before removal from the matrix. This help is very much appreciated on the part of the Survey, and has assisted to no small degree in the study of the fullers earth bearing formation.

The fullers earth of Gadsden county occurs as strata interbedded between sandstone or bluish to yellowish sands, varying in places to calcareous and shell bearing marls. The fullers earth itself rarely contains fossils. However, both vertebrate and invertebrate remains are occasionally found in the sandstone stratum lying between the two strata of fullers earth. It is principally from this sandstone material after it has been dug out and hauled to the "dump" that the fossils have been obtained. Of the vertebrate fossils thus found the tooth of the early horse, *Merychippus*, may be mentioned as the most characteristic.* Much material of value to science has been obtained through careful search of the mines of Gadsden county and through the help of the miners themselves, who are assisting in the work of preserving any fossils found in the fullers earth bearing formation. It is hoped that this assistance will be continued and that more determinate material may be secured. The fullers earth beds lie within the Alum Bluff formation which, as indicated by the fossils, is of Miocene age.

* Fla. Geol. Surv., Eighth Ann. Rept., pp. 87-88, 1916.

An account of the fullers earth deposits of Gadsden county was given in the Second Annual Report of this Survey in 1909. This is now out of print and the following has been adapted from this report, with some omissions, and additions where necessary, in order to bring the matter relative to the deposits up to date.

Fullers earth is a clay differing from other clays chiefly in that it is light and porous, and possesses in a high degree the quality of absorbing greasy substances. This earth was formerly used in removing grease and fats from cloth in the process of fulling, from which usage it received the name of fullers earth. But little earth is used for this purpose at the present time, soaps and alkalies having almost entirely replaced it.

Fullers earth, like other clays, is complex. It consists not of a single mineral, but of a variety of minerals; the mineral particles being mixed in widely varying proportions, resulting in a variable chemical and mineralogical composition. Under the microscope the Gadsden county fullers earth shows angular particles of quartz together with green double refracting particles which Merrill regards as a siliceous mineral.* In fullers earth from Arkansas, Merrill observed sharply angular colorless mineral particles, faintly double refracting, but lacking crystal outlines or other physical properties such as would determine their exact mineral nature. Angular particles of quartz and a few yellowish iron-stained particles suggestive of residual products from decomposition of iron magnesia silicates were also recognized in this sample. The fullers earth from Surrey, England, according to the same writer, consists of extremely irregular eroded particles of a siliceous mineral and of minute colorless particles suggestive of a soda lime feldspar. Thus it may be said that while fullers earth is known to consist like most other clays of a mixture of minerals it is often difficult to make a satisfactory determination of the individual mineral constituents.

Chemical Constituents:—There is a wide range in variation in the chemical constituents of different fullers earths, or fullers earth from different localities. The range of individual constituents may be inferred from the accompanying analyses.

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* Report of the U. S. Nat. Museum, 1899, p. 338.

ANALYSES OF FULLERS EARTH FROM VARIOUS LOCALITIES.

	I.	II.	III.	IV.	V.	VI.
Silica (SiO_2)	62.83	67.46	58.72	50.36	74.90	63.19
Alumina (Al_2O_3)	10.35	10.08	16.90	33.38	10.25	18.76
Ferric Oxide (Fe_2O_3)	2.45	2.49	4.00	3.31	1.75	7.05
Lime (CaO)	2.43	3.14	4.06	----	1.30	0.78
Magnesia (MgO)	3.12	4.09	2.56	----	2.30	1.68
Potash (K_2O)	0.74	----	2.11	.88	1.75	0.21
Soda (Na_2O)	0.20	----				1.50
Water (H_2O)	7.72	5.61	8.10	12.05	5.80	7.57
Moisture	6.41	6.28	2.30	----	1.70	----

No. I. From Gadsden County, Florida, U. S. Geol. Sur. 17th Ann. Rept. pt. iii (cont.) page 880.
No. II. From Decatur County, Georgia. Ibid.
No. III. From Fairburn, S. D. Ibid.
No. IV. Glacialite, Enid, Okla. G. P. Merrill, Non-metallic Minerals. U. S. Nat. Mus., Rept. for 1899, p. 337, 1901.
No. V. From Sumter, S. C., U. S. Geol. Surv., Min. Reso., 1901, p. 933, 1902.
No. VI. From Alexander, Ark. Branner, Amer. Inst. Min. Eng. Trans. XXVII, p. 62, 1898. Ries, Clays, p. 465, 1906.

Physical Properties:—The most distinctive physical property of fullers earth is that of clarifying oils.

Test for Fullers Earth:—Fullers earth varies in color. That found in Florida is mostly light buff, brownish or yellowish, or olive green, gray or blue. It is not readily distinguished in general appearance from other clays. It is light and porous and when dry adheres firmly to the tongue, but some other clays are also adhesive. A practical test of fullers earth is necessary in order to determine its value. A test may be made by the use of a glass tube ½ to 1 inch in diameter and 2 to 3 feet long. To make the test, support the tube in an erect position, the lower end being plugged with asbestos fiber. The earth is powdered and packed into the tube. A mineral oil is then passed through it. If the clay is a fullers earth the oils will be more or less perfectly clarified, depending upon the quality of the earth. It is reported that a fullers earth that will clarify a mineral oil may not affect a vegetable oil, while an earth used to clarify a vegetable oil may be unsatisfactory when applied to a mineral oil. A theory of the action of fullers earth in clarifying oils is given by Porter as follows (U. S. Geol. Surv. Bull. 315, p. 282, 1907): "Fullers earth has for its base a

series of hydrous aluminum silicates. These silicates differ in chemical composition, but are similar in that they all possess an amorphous colloidal structure. These colloidal silicates possess the power of absorbing and retaining organic coloring matter, thus bleaching oils and fats."

Uses:—The Florida fullers earth finds its chief use in filtering mineral lubricating oils. According to Day, "The common practice with these mineral oils is to dry the earth carefully, after it has been ground to 60 mesh, and run it into long cylinders, through which the crude black mineral oils are allowed to percolate very slowly. As a result the oil which comes out first is perfectly water-white in color, and markedly thinner than that which follows. The oil is allowed to continue percolating through the fullers earth until the color reaches a certain maximum shade, when the process is stopped, to be continued with a new portion of earth. The oil is recovered from the spent earth."* It is also used to some extent for lightening the color of cotton seed oil, and lard oil, although the English fullers earth is better for these purposes. The original use of fullers earth, that of cleaning, is now one of the minor uses. It is said to be used in the manufacture of some soaps. It is used in cleaning furs and by druggists as an absorbent.

Methods of Mining:—Originally the overburden in the Gadsden county fullers earth mines was removed by pick and shovel. At the present time, however, the overburden is removed chiefly by steam power and hydraulicking. The depth of overburden that can be profitably removed is determined entirely by the depth and character of the fullers earth deposit. The overburden removed in the mines which are now being worked varies from one or two, to twenty or twenty-five feet. The greater part of this overburden is more or less decayed and residual in character and is readily removed. With some of the harder material, loosening by blasting becomes necessary.

The fullers earth itself is mined in the open pit by pick and shovel, and by steam shovel, being loosened when necessary by blasting. From the pit it is loaded by shovel into "dummy" cars and is drawn either by cable or by small engine to the plant nearby.

At the plant the fullers earth is taken to the store house. The

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*U. S. Geol. Surv., 21st Ann. Rept., pt. 6 (cont.), p. 592, 1901.

larger pieces are first broken by pick or sledge and the material then passed through a crusher. After passing through the crusher the material, now broken into pieces, one to two or three inches in size, is fed automatically into a drying cylinder heated by crude petroleum. These cylinders which are 30 to 40 feet long and five or six feet in diameter, revolve slowly and by means of half cups set at an incline move the fullers earth forward with each revolution. A high temperature is not sought in the cylinder as used in Florida, the object being to remove the surface moisture from the clay. The fullers earth passes through the cylinder slowly, each piece of clay occupying fifteen to twenty minutes in transit. The fullers earth upon dropping from the cylinders after drying is carried to a storage bin, and is there fed to the mills for grinding as needed. The ground material is passed through bolters and separated into the grades desired for commercial purposes. After bolting, the earth is sacked for shipment and is labelled according to the degree of fineness. The grade most used in refining mineral oils is about 30-60 by which is meant fullers earth ground to a fineness which permits it to pass through a thirty mesh screen but not sufficient to permit it to pass a sixty mesh screen. The finer grades find other uses.

LIMESTONE.

The limestones of this area, all of which are of the Chattahoochee formation, are found principally in the western part of Gadsden county along the Apalachicola river. There are, however, some limited surface exposures of this limestone in the northeastern part of this county.

The Chattahoochee Limestone is extensively exposed in the vicinity of River Junction. The rock here might be termed an argillaceous limestone and some years ago was used for the manufacture of a natural hydraulic cement. The output of cement from this limestone for the year 1898 is given as 7,500 barrels.* The limestones within this area are not at present utilized although in Wakulla county, which lies just east of this area, limestones of this formation are quarried and sold for road and concrete material and for agricultural purposes.

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* U. S. Geol. Surv. 20th Ann. Rept., pt. VI (cont.), p. 547, 1899.

PHOSPHATE.

No workable phosphate beds are known in this area. The Alum Bluff formation, however, carries some phosphate, although probably not in commercial quantities. The type locality of this formation is at Alum Bluff on the Apalachicola river in Liberty county. The bluff here consists chiefly of gray phosphatic and calcareous sands. A detailed section of this bluff will be found on page 45 of this report. Of special interest in connection with a discussion of phosphate in this area is the fact that the Alum Bluff formation, the type locality of which is in Liberty county, forms the bed rock of the workable pebble phosphate deposits and is the parent formation from which the pebble phosphate deposits were derived.*

The following are analyses of the light gray calcareous and phosphatic sandstones of the Alum Bluff formation. Samples from which these analyses were made were collected by the writers in 1909 in connection with the preparation of a report on the fullers earth of Gadsden county and were reported upon in the Second Annual Report of this Survey, pages 275-276. No. 1 is from Rock Bluff; No. 2 is from Alum Bluff; No. 3 is from an exposure on a tributary to Sweet Water Creek on S. 5, T. 1 N., R. 7 W.

Analyses made for the State Survey in the office of the State Chemist, B. H. Bridges, Analyst.

	No. 1.	No. 2.	No. 3.
Silica (SiO_2)	48.44	53.02	34.03
Calcium carbonate ($CaCO_3$)	38.57	38.57	35.35
Magnesium carbonate ($MgCO_3$)	1.68	1.84	26.00
Iron and Alumina (Fe_2O_3 and Al_2O_3)	2.88	3.96	3.20
Phosphoric acid (P_2O_5)	Trace	0.22	Trace
Sulphate (SO_4)	Trace	Trace	Trace
Moisture (100 degrees F.)	1.37	1.60	1.32

An additional sample of the gray phosphatic rock of this formation collected in 1909 by E. H. Sellards was analyzed in the State Chemist's office with the following result:

* Fla. Geol. Surv. Seventh Ann. Rept., pp. 34-35, 1915.

Silica (SiO_2)	34.03
Calcium oxide (CaO)	19.80
Magnesium oxide (MgO)	12.39
Iron and Alumina (Fe_2O_3 and Al_2O_3)	3.20
Phosphoric acid (P_2O_5)	Trace
Sulphate (SO_4)	Trace
Moisture (H_2O)	1.32

Samples of rock sent in to the State Chemist's office for analysis and reported to come from this formation in Liberty county, were found to contain from 32.66 per cent to 69.25 per cent of bone phosphate of lime. These analyses are recorded as numbers M438, M442 and M985 in the reports of the Florida State Chemist. They probably represent localized enrichment in rock that, as a rule, is of low grade.

ROAD MATERIALS.

The principal road building materials of this area are sandy clays, limestones and recent oyster shells. The clays are very generally distributed over the northern part of Gadsden county and the west central portion of Liberty county. The limestones are found chiefly in the western part of Gadsden county, but have not up to the present been used for road surfacing. Recent oyster shells are extensively used as road material in the southern part of the area in Franklin county.

WATER SUPPLY.

The water supply in this area is obtained principally from deep and shallow wells and springs. The well from which the city water supply at Quincy is taken has a depth of 766 feet. Other artesian wells in this vicinity range in depth from 602 to 940 feet. Shallow wells range in depth from 50 to 90 or more feet and give a good supply of soft water. The city well at Apalachicola has a depth of 363 feet and the water rises in the casing to within about 6 feet of the surface. Flowing artesian wells are obtained along the bay shore at depths of from 325 to 620 feet. The water from the deeper wells contain more or less salt. At Carrabelle the Carrabelle Ice Company own a well reported 1,018 feet deep. This

well does not flow, the water standing about 6 feet below the surface. Flowing wells are obtained, however, near Carrabelle and for some miles up New river. These range in depth from 130 to 356 feet. In Liberty county at Hosford the water supply is obtained from a well 495 feet in depth. The water from this well is reported to rise to the surface.

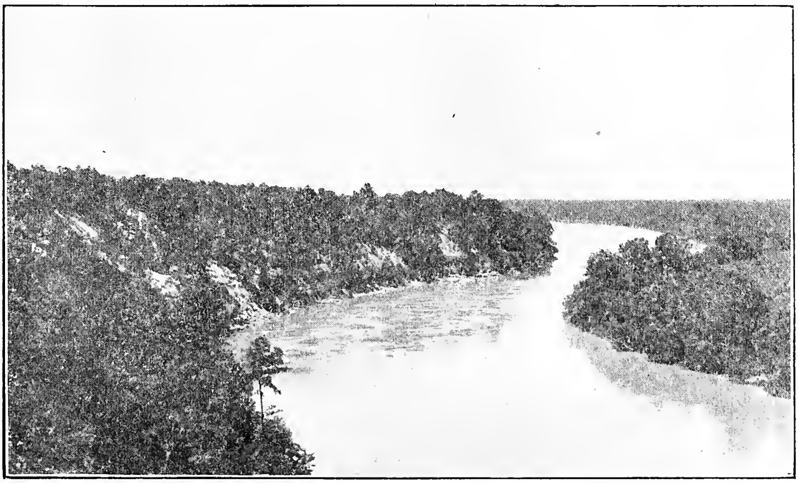

Fig. 1. The Apalachicola River looking south from Alum Bluff.

TOPOGRAPHY AND GEOLOGY.

E. H. SELLARDS.

The uplands in this area include a plain or plateau which is highest at the north or northwest, where it reaches an elevation of from 300 to about 325 feet above sea. The plain as now preserved slopes to the south, east and southeast. The slope to the south, especially just east of the Apalachicola river, may approximate the original dip slope of the plain. The slope to the east and southeast possibly has been somewhat accentuated by surface erosion and removal of the disintegrated materials by surface wash. The average rate of slope of the plain from the State line to the Gulf is approximately 300 feet in 60 miles, or an average of about 5 feet per mile.

This plain is cut across by the Apalachicola and the Ocklocknee rivers, and is cut into by the numerous streams tributary to these rivers. The most rugged land of this area is that which borders the Apalachicola river in Gadsden and the northern part of Liberty counties. The plateau here rises from the river abruptly. The small streams tributary to the Apalachicola river have cut short deep channels back into the plateau, producing over a small area the most hilly section found in Florida.

STREAM VALLEYS.

This area presents some topographic features of exceptional interest. The two principal streams, the Apalachicola river on the west and the Ocklocknee river on the east, each have a northeast-southwest course through the northern half of this area and, in this part of their course, both streams have developed pronounced bluffs on their left or east banks. This is notably true of the larger of these streams, the Apalachicola river. The bluffs immediately on the east side of this river rise to an elevation of as much as from 150 to 225 feet above the river valley. On the west side, on the contrary, the banks are low and the rise to the high land is very gradual. This lack of symmetry is due in part to the fact that the streams are working down the dip of the formations which is to the south and southeast. Hence they impinge more strongly on their left than on their right bank. Another and perhaps a

more effective cause for the high bluffs on the east side is found in the history of the development of the tributaries. Those tributaries that flow with the dip extend their course inland more rapidly than those that work against the dip. Those streams flowing with the dip receive a better and more constant supply of water from springs than do the other streams. This increased supply of water facilitates both the extension and the deepening of the stream channels. The greater development of the drainage system is accompanied by an increased amount of erosion and surface wash. In this way the average land level on the west or northwest side of the main stream has been more rapidly reduced than on the east side. Instead of the typical V-shaped valleys, the streams in this area, for the most part, are bordered on one side by bluffs, more or less pronounced, while on the other side, the land rises gradually to the plateau level.

STEEPHEADS.

A characteristic feature of this topography is the development of what is known locally as "steepheads." These steepheads are due to the fact that indurated sands and sandy clays overlie slightly indurated sands and clays and shell marls. The surface waters pass into the earth and, upon reaching the underlying clay or marl beds, emerge as springs. The indurated sandy clays near the surface stand up vertically, while the softer sands, at a greater depth where the springs emerge, wash easily. The result is the formation of a nearly vertical bluff, at the base of which springs emerge supplying small streams. This bluff or streamhead assumes in time a semi-circular form, which is the "steephead." The steephead thus formed is retained by the stream as it gradually extends its way back into the plateau. The depth of the steephead from the plateau is usually from 50 to 60 or more feet, depending upon the depth at which the ground waters emerge as springs.

GEOLOGY.

The geologic formations found at the surface within this area are chiefly of Oligocene and Miocene age, although more recent deposits may overlie these near the coast. The materials of these formations include limestones, sands, clays, sandy clays, and shell marls. The shell marls are those of the Alum Bluff and Choctawhatchee formations (Miocene). The limestones are chiefly those of the Chattahoochee formation (Oligocene), although more recent limestones are found in places near the coast.

The following table presents a summary of the formations of this area, as understood at the present time, all of which are of Cenozoic age:

Pleistocene—No marine fossiliferous Pleistocene known within the area.
Pliocene-Miocene—Chiefly coarse sands and unfossiliferous sandy clays.
Pliocene—Marine Pliocene may be present near the coast.
Miocene—Choctawhatchee formation; shell marls and sands.
Miocene—Alum Bluff formation; calcareous sands and clays.
Oligocene—Chattahoochee formation; limestones and calcareous clays.
Eocene—Not exposed at the surface, although probably reached by the deepest wells.

OLIGOCENE.

CHATTAHOOCHEE FORMATION.

The type locality of the Chattahoochee formation is within this area at the Chattahoochee Landing on the Apalachicola river in Gadsden county. The thickness of the rock exposed in the cut for the public road at this landing is as much as 65 feet, and the full thickness of the formation is evidently considerably greater. The rock of this formation as exposed at this place consists of rather impure limestone, the impurity being chiefly clay. The deposits are stratified, ledges of rock of medium hardness alternating with softer, more clayey or marly layers. The inclusion of clay in the rock is about in the proper proportion to form a natural cement, the rock nearby at River Junction having formerly been used in a limited way for that purpose.

The Chattahoochee limestone underlies the whole of this area

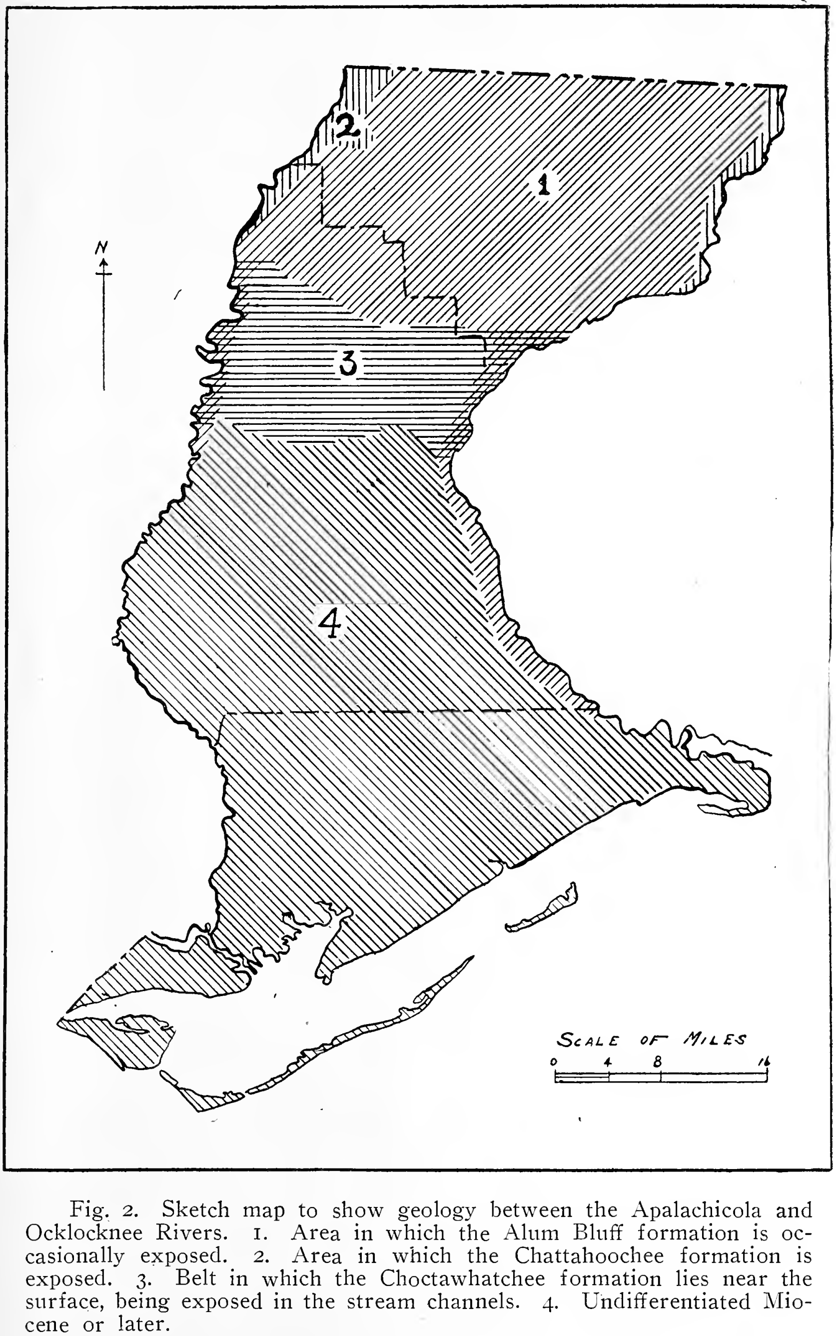

Fig. 2. Sketch map to show geology between the Apalachicola and Ocklocknee Rivers. 1. Area in which the Alum Bluff formation is occasionally exposed. 2. Area in which the Chattahoochee formation is exposed. 3. Belt in which the Choctawhatchee formation lies near the surface, being exposed in the stream channels. 4. Undifferentiated Miocene or later.

and is exposed on the Apalachicola and Ocklocknee rivers. It dips and passes below the surface before reaching the Gulf. The Apalachicola river, which forms the western boundary of this area, flows across this limestone from the State line to somewhat below Rock Bluff in Liberty county, where the limestone passes below water level. The Ocklocknee river at the east side of the area flows on this formation from the State line to the crossing of the Seaboard Air Line Railway, where the rock passes below water level. Although exposed on these river channels, in the hills and on tributaries for some distance back from the main streams, the formation elsewhere in this area is concealed by the later formations.

The fossils of the Chattahoochee formation are, for the most part imperfect. Of vertebrates, no recognizable species have been obtained, although broken pieces of ribs, probably of cetaceans, are not uncommon. Invertebrates are not numerous in the formation as exposed in this area, and are preserved, for the most part, as casts.

SURFACE EXPOSURES OF THE CHATTAHOOCHEE LIMESTONE.

As already noted, the principal surface exposures of the Chattahoochee limestone are those found on the channels of the Apalachicola and Ocklocknee rivers. The exposures on the Apalachicola river were described in some detail in the Second Annual Report of the Florida Survey.* Some of the more important of the sections on the Apalachicola river, so far as they include this formation, are here reproduced from this earlier report. Among the localities where exposures of this formation may be seen are Chattahoochee Landing, Aspalaga Bluff and Rock Bluff. In all of these sections the measurements were referred to the water level at the stage of March 5, 1909. At that time the water on the gauge at the railroad bridge at River Junction was 7½ feet, or about 51 feet above sea level.

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*The Fullers Earth Deposits of Gadsden County, with notes on similar deposits found elsewhere in the State. By E. H. Sellards and Herman Gunter, Fla. Geol. Surv., 2nd Ann. Rpt., pp. 253-291, 1909.

SECTION AT CHATTAHOOCHEE LANDING.

The section at Chattahoochee Landing is made along the public road leading from Chattahoochee to the river. The exposure begins about one-fifth mile from the river, and is measured along the public road a distance of perhaps somewhat more than one-fourth mile to the top of the plateau. In the lower part of the section while crossing the Chattahoochee limestone the road runs in a direction northwest to southeast. At the top of this first part of the hill the road turns almost at a right angle to the northeast, again turning east as the top of the last hill is reached.

		Thickness of stratum.
12.	Rich red sand containing, especially toward the base, an abundance of siliceous pebbles, light colored or stained brown by iron. The sand becomes coarser toward the bottom. Feeble cross-bedding and stratification is seen. A layer of iron concretions occurs 13 feet from the base, or 15 feet from the top	28 feet
11.	Pinkish and purple sandy clays in horizontal position	9 feet
10.	Covered and sloping	42 feet
9.	Marly limestone	4 feet
8.	Covered and sloping	14 feet
7.	Light colored clayey limestone, with clay inclusions near the top	26½ feet
6.	Sandy pale yellow limestone	4 feet
5.	Lime clay stratum similar in character to that found at Aspalaga Bluff, the top of which in that section lies at the north end of the bluff 19¾ feet above the river at same stage of water	3¾ feet
4.	Clayey limestone, alternating ledges of harder material with lime clay strata intervening	16½ feet
3.	Stratum of greenish calcium carbonate crystals imbedded in a soft marly matrix	1 foot
2.	White soft clayey limestone with ledges of harder, more compact limestone. Some shells as casts and also occasional manatee ribs are found in this part of the section	12 feet
1.	Covered from the river to the base of the section a distance of about one-fifth mile	21¼ feet

SECTION AT ASPALAGA BLUFF.

Aspalaga Bluff is seven miles in a direct line from the north boundary of the State and is the first point in Florida at which the river channel strikes the east bluff. The following section was made near the north end of that part of the bluff facing the river. A continuous exposure is not found in any direct line of sectioning. In order to determine thickness of strata it is often necessary to transfer the level for short distances along the side of the bluff.

		Thickness of stratum.
12.	Covered in the line of sectioning to the top of the bluff about one-fourth mile back from the river, about	60 feet

11.	Sloping and covered except for occasional outcrops of impure limestones mostly containing fossils as casts	51 feet
10.	White granular limestone with numerous shells as casts	2 feet
9.	White limestone becoming upon exposure hard and of a pinkish color (exposed)	4 feet
8.	Steep slope partly covered but with frequent and almost continuous exposures of light colored impure limestone often with clay inclusions	23 feet
7.	White granular limestone with numerous fossils as casts	1 foot
6.	White limestone becoming upon exposure hard and of a pinkish color	2½ feet
5.	Light colored limestone weathering rough	2 feet
4.	White limestone becoming upon exposure hard and of a pinkish color	6 feet
3.	Sandy light to pale yellow limestone	2¾ feet
2.	Gray to bluish calcareous clay which upon drying breaks with a tendency to conchoidal exfoliation	4 feet
1.	Limestone at the base to water's edge yellowish and sandy with few fossils, above lighter colored with small fossils as casts, near the top clayey	15¾ feet

The calcareous clay (No. 2) of the Aspalaga section forms a very characteristic stratum. This stratum seen in numerous exposures from Chattahoochee to Aspalaga is very porous and of light specific gravity, and except for the presence of calcium carbonate has many resemblances to fullers earth. The following is an analysis of a sample from Aspalaga. Analysis made for the State Survey in the office of the State Chemist, B. H. Bridges, Analyst.

Silica (SiO_2)	39.08
Calcium oxide (CaO) 12.00, $CaCO_3$ (calculated)	21.80
Magnesium oxide (MgO) 8.86, $MgCO_3$ (calculated)	18.48
Iron and alumina (Fe_2O_3), Al_2O_3	11.60
Phosphoric acid	00.00
Sulphate (SO_4)	Trace
Moisture (100 degrees F.)	1.50

STRUCTURE.

While relatively few exact elevations have been available, an approximate determination of the actual level of the rock exposures of this formation have been made at a number of localities, which have been of service in determining the structure of this formation. The exact level at River Junction is available through bench marks established by the U. S. Coast and Geodetic Survey and by the U. S. Army Engineers. The water level in the river at Blountstown has been determined from levels on the Blountstown-Marianna railway kindly made available through the courtesy of

Mr. Arthur Pew. The levels at intervening points on the river between River Junction and Blountstown are obtained approximately by averaging the fall in the water level of the river from River Junction to Blountstown. On the Ocklocknee river, approximate levels have been obtained by utilizing levels on the Seaboard Air Line railway and on the Georgia-Florida and Alabama railway, which have been kindly supplied by these two roads.

The highest exposure in the Chattahoochee Landing section recognized as representing the Chattahoochee formation is at an elevation of 85 feet above the river. The water level in the river at the time this section was made was about 51 feet above the sea.* Accordingly the top of the Chattahoochee formation, as nearly as can be determined, is about 136 above sea at this exposure.

At Aspalaga Bluff the water level in the river is estimated to be about 5 feet lower than at the railroad bridge at River Junction.† In this section limestones apparently of the Chattahoochee formation are exposed to an elevation of 63 feet above the rirver, or 110 feet above sea.

Rock Bluff is 12 miles in a direct line down the river from River Junction, and the water level in the river at this bluff was estimated to be about 8 feet lower than at River Junction, or 42 feet above sea.† The Chattahoochee limestone in this bluff stands about 10 feet above water level, the top of the formation at this place being apparently about 52 feet above sea.

On the Griffin place, about 2 miles below Rock Bluff (S 31,

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*At the time this section was made in 1909 the gauge on the bridge at River Junction read 7½ feet. Since that time, however, the bridge has been rebuilt. The bottom of the present gauge is about 43½ feet above sea level. Assuming that the gauge on the new bridge was placed at approximately the same level as on the old bridge, the water level at the railroad bridge on March 5, 1909, was about 51 feet above sea level. Chattahoochee Landing is less than one mile above the railroad bridge, hence the water level differs by probably less than one-half foot from that at the bridge. Accordingly, as an approximate measurement, it is assumed that the water level in the river at the time this section was made was about 51 feet above sea.

†On March 5, 1918, the water level n the river at River Junction was 48.6 feet above sea. On the same date the water level in the river at the landing at Blountstown was 35.4 feet, indicating a fall in water level of 13.2 feet from River Junction to Blountstown, a distance in a direct line of about 20 miles. The average fall of the river in this part of its course is therefore approximately .65 feet per mile.

T 2 N, R 7 W), limestone rock which probably represents the Chattahoochee formation, was thrown out from the bottom of a well. The well is near the mouth of Sweetwater creek, and the rock which was reached at a depth of 10 or 12 feet, appears to lie somewhat below water level in the river, or probably at an actual elevation of approximately 40 feet above sea.

This locality on Sweetwater creek is the last known occurrence of the Chattahoochee limestone on this river above water level. The distance from Chattahoochee Landing, where the top of the formation is 136 feet above sea, to this locality in a direct line is about 15 miles. The dip of this formation in the direction of the flow of the river, which in this part of its course is southwest, is therefore 96 feet in 15 miles, or approximately an average of 6.4 feet per mile. The writers' former estimate of the rate of dip of this formation was 7 feet per mile.* If the dip of the limestone is computed from ½ mile south of River Junction, where the Chattahoochee formation appears to reach an elevation of 148 feet, the dip amounts to 105 feet in about 14 miles, or 7.5 feet per mile. The actual average dip is probably close to the estimate formerly given of 7 feet per mile. Minor folds in this formation which result in pronounced dips over limited areas have previously been described.* Elevations on the top surface of this formation are indicated on the sketch map, figure 2.

Limestone rock, which probably represents Chattahoochee formation, is exposed on the east bank of the Ocklocknee river, about 1 mile above the Fairbanks bridge near the Georgia-Florida State line (S 12, T 3 N, R 1 W). In a bluff facing an abandoned channel of the river this rock was found in place at an elevation of 13 feet above water level. The water level in the river at this place was estimated by its relation to Lake Iamonia, the level of which is known to be about 95 feet above sea. Accordingly, the top surface of the rock at this place is about 108 feet above sea. A similar rock is exposed in a sink on Parrott's Mill creek about three-fourths of a mile west of Fairbanks bridge on the Ocklocknee river (S 15, T 3 N, R 1 W). The level of the top surface of the rock at this exposure is 5 feet above the water in the river or about 100 feet above sea level. In a sink on Ponto creek about three-fourths

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* Fla. Geol. Surv., 2nd Ann. Rpt., pp. 277-278, 1909.

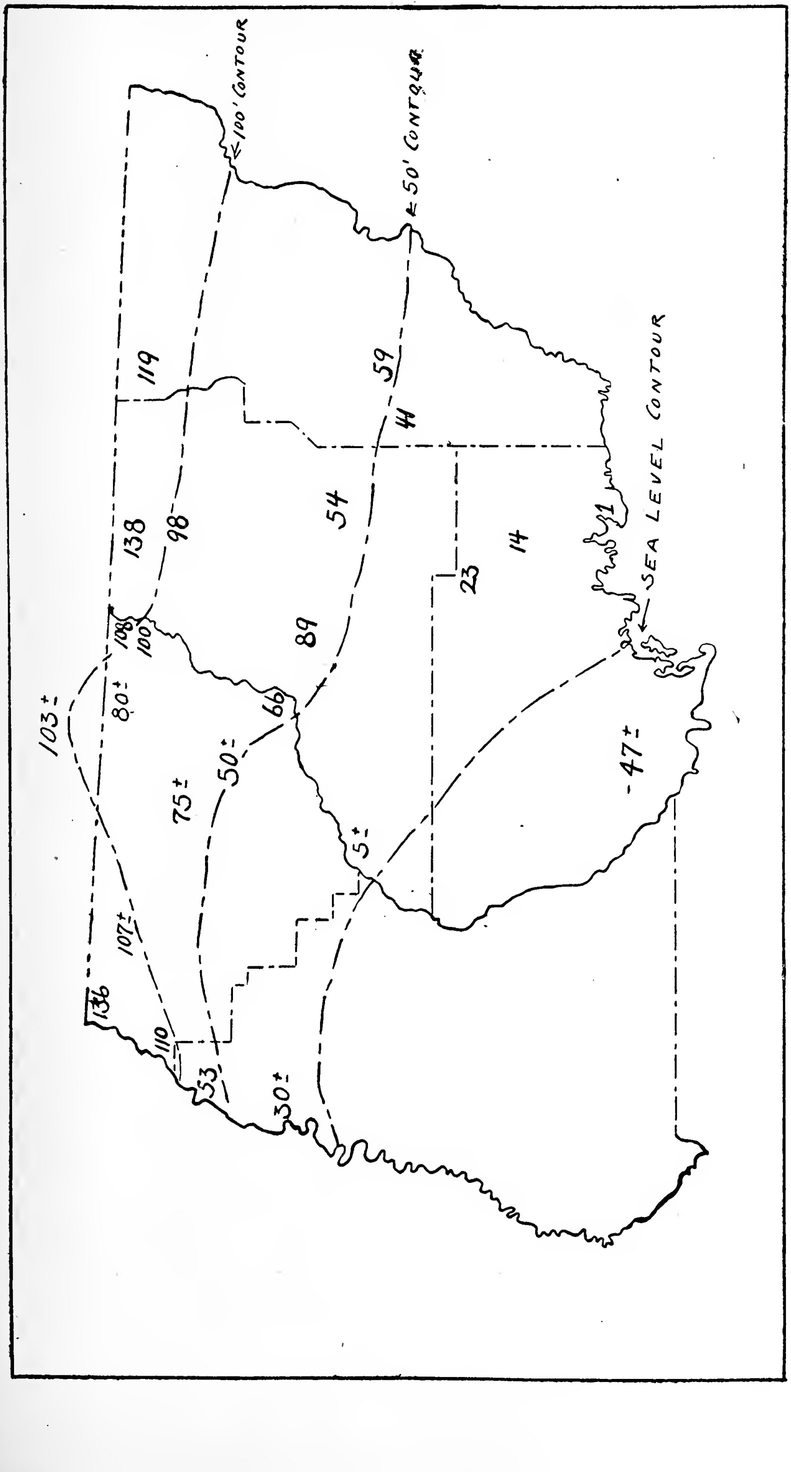

Fig. 3. Elevations and contours on the top surface of the Chattahoochee formation. The elevations followed by the "plus-minus" sign are inferred levels. With one exception, they have been obtained by deducting from the known level of the fullers earth horizon 70 feet, that being the approximate interval between that horizon and the top of the Chattahoochee formation.

of a mile west of this locality, the calcareous and phosphatic phase of the Alum Bluff sands, including silicified oysters, is found in place at an elevation of 10 feet above the water level of the river. In Leon county, north of Lake Iamonia, the Chattahoochee limestone was reached in a well at an elevation of 135 feet above sea, while at a place nearby known as the "Cascades," the rock is exposed at an elevation of 127 feet above sea. This data indicates that the limestones of this formation lie at a higher level on the east side of the Ocklocknee river than immediately on the west side.

The Chattahoochee limestone is well exposed on and near the public road one-half mile south of River Junction. The highest exposure of the light-colored rock on this hill was found to be 165 feet above sea. Upon examining the rock, however, it appeared probable that the uppermost part of the exposure, including about 20 feet, represents an indurated phase of the Alum Bluff formation. Accordingly, the top surface of the Chattahoochee limestone in this exposure is probably not more than 148 feet above sea.

On the Apalachicola Northern railway about three and one-half miles southeast of River Junction is a rock exposure which is probably near the top of the Chattahoochee formation, or the base of the Alum Bluff formation. The approximate level of the top surface of the rock at this place as determined from the profile of the Apalachicola Northern railway, is 120 feet above sea.

On the Ocklocknee river at the crossing of the Seaboard Air Line railway limestone rock which apparently represents the Chattahoochee formation is exposed at an elevation of 66 feet above sea. This exposure is about 28 miles east-southeast of River Junction. The dip of the formation in this direction, as determined from these exposures, accordingly appears to be 79 feet in 28 miles, or an average slightly less than 3 feet per mile.

There is reason to believe, however, that the dip is actually more rapid than is indicated by these measurements. At the public road crossing on Little river west of Midway the oyster shell marl phase of the Alum Bluff formation is exposed at water level. The level in the bed of Little river at the Georgia, Florida and Alabama railway crossing (Quincy Branch) about five miles up stream from this place is about 82 feet above sea. The fall of this stream approximates 3 feet per mile. While the actual elevation of the exposure of shell marl near Midway is not known it may be safely

placed as very close to 70 feet above sea. From this record it appears that the Chattahoochee formation lies as low, if not lower, on Little river than on the Ocklocknee river. The dip of the Chattahoochee formation south of east, therefore, amounts to as much, at least, as between 75 or 80 feet in 21 miles, or about 4 feet per mile. The dip may be greater since the top of the Chattahoochee formation is not actually exposed in Little river. These measurements which are consistent with others previously obtained indicate that the Chattahoochee formation dips to the east from River Junction and rises somewhat again at the Ocklocknee river.

A slight interruption in the dip of this formation was first suggested by the writer to account for the anomalous course of the Ocklocknee river*. At that time it was pointed out also that the topography supported this suggestion, since east of the Ocklocknee there has been developed lakes occupying solution basins in the limestone, and with these a characteristic limestone topography, while in the belt of country immediately west of the river, on the other hand, there are almost no indications of limestones lying near the surface except in the extreme northeast part of Gadsden county, and of course at the extreme west along the Apalachicola river. Measurements subsequently made indicate that near the Georgia line the base of the Alum Bluff formation is close to 105 feet above sea (sink of Ponto Branch), while a few miles farther east in Leon County the Chattahoochee limestone rises to an elevation of 127 and 135 feet at the recorded exposures. It would seem therefore, that as indicated both by topography and stratigraphy, there is a slight interruption of dip near the Ocklocknee river.

MIOCENE.

THE ALUM BLUFF FORMATION.

The Alum Bluff formation which lies next above the Chattahoochee, includes clays, fullers earth, calcareous and phosphatic sands, and sandy clays. The type locality of this formation is at Alum Bluff, in Liberty county. The formation is well shown also at many other localities throughout the area. The maximum ex-

* Florida Geol. Surv., 9th Ann. Rpt., pp. 130-132, 1917.

posure of this formation is found at Rock Bluff on the Apalachicola river. The following section at Rock Bluff made in 1908 is from the Second Annual Report of the Florida Survey, page 273.

SECTION AT ROCK BLUFF.

Rock Bluff lies five and one-half miles in a direct line south of southwest of Aspalaga Bluff, or twelve and one-half miles from the State line. It is the second point at which the river in Florida strikes the east border of the river valley. That part of Rock Bluff which faces the river lies near the southwest corner of Section 17, R. 7 west, T. 2 north. The basal part of the following section is made near the north end where the river channel first strikes the bluff. From this point the level was transferred north across a small stream to that part of the bluff which does now directly face the river.

		Thickness of stratum.	
11.	Covered in the line of the section to the top of the bluff from the river, about ¼ mile	100	feet
10.	Fullers earth (exposed)	3	feet
9.	Ledge with shells	1	foot
8.	Gray sand	5	feet
7.	Ledge with shells	2	feet
6.	Gray sand with lime inclusions	5	feet
5.	Covered	2	feet
4.	Light gray calcareous sand containing a trace of phosphate (by transferring the level across a small branch to the north the section is continued)	30	feet
3.	Bluish green to gray sands, variable in character. Lime inclusions begin to appear in these sands at 20 feet from the base. These become more numerous until the material passes gradually into the sandy-marl above	34	feet
2.	Compact sandy marl with concretions near the base and with an ostrea layer 6 feet above the base	8	feet
1.	Chattahoochee limestone above water level	10	feet

Numbers 2 to 10 of this section are believed to represent the Alum Bluff formation, which here has a thickness of 90 feet. In addition, the uppermost part of the formation, including that part which lies above the fullers earth horizon, is not exposed, or is wanting.

The Alum Bluff formation includes, in places, marl beds, containing a rich and varied invertebrate fauna. The Chipola marl at the base of this formation at Alum Bluff is one of the localities where large collections have been made. In addition to the marine invertebrates, both land plants and land animals have been ob-

tained from this formation. The fossil plants are found at Alum Bluff, on the Apalachicola river.* The vertebrates from this formation have been obtained at the fullers earth mines at Midway and at Quincy, and have been described in the Eighth Annual Report of this Survey, pp. 82-92, 1916. The fossils indicate that the formation is of Miocene age.

STRUCTURE.

The numerous exposures of this formation make it possible to use it to supplement the data on structure obtained from the Chattahoochee formation. On the Ocklocknee river this formation remains above water level to tidewater, exposures having been noted as far down stream as Sanborn Ferry. On the Apalachicola river the exposures below Alum Bluff are not numerous. At Estiffanulga, about 10 miles in a direct line below Blountstown, there is exposed on the river bluff about 20 feet of prevailingly coarse cross-bedded sands which have the lithologic characteristics of the upper part of the Alum Bluff formation. Aside from petrified wood, no fossils were found at this exposure. The elevation at the top of this bluff is probably 45 or 50 feet above sea. Little river flows on or cuts its channel into this formation from the State line to its union with the Ocklocknee river, the gradient of this stream being approximately equivalent to the dip of this formation. Many of the tributaries of the Apalachicola, Ocklocknee and Little rivers cut across and expose the strata of this formation.

Perhaps the most convenient horizon to use in determining the elevation of exposures within this formation is that of the fullers earth deposits. The fullers earth strata are not continuous, but are found, so far as observed, at a definite horizon within the formation. When typically developed the formation contains two layers of fullers earth separated by a stratum of sandstone. The fullers earth layers vary in thickness from 2 to 3 to 7 or 8 feet, while the intervening sandstone is from 1 to 3 feet thick. The fullers earth itself varies from light earth of commercial value to heavy earth that is not adapted for commercial use.

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* The Physical Condition and Age Indicated by the Flora of the Alum Bluff Formation. By Edward Wilber Berry, U. S. Geol. Surv., Prof. Paper 98-E, 1916.

In using the fullers earth strata it is frequently impossible to determine whether the exposure in question represents the upper or the lower of the two layers. However, as the total combined thickness of the two layers seldom exceeds about 15 feet, this discrepancy is not serious. The exposure at Rock Bluff indicates that there is in places at least as much as 90 feet of calcareous and phosphatic sands of this formation below the fullers earth. On the other hand, at the pit of the Fullers Earth Company at Midway, may be seen as much as 25 feet of cross bedded and in places slightly calcareous sand of this formation above the fullers earth. Allowing 15 feet for the combined thickness of the fullers earth beds, the whole thickness of this formation is not less than 125 or 130 feet, and may be considerably more.

In the public road about 1½ miles southeast of River Junction is an exposure of fullers earth which may represent either the upper or the lower stratum of this horizon. A line of levels run from the bench mark at River Junction indicated for this exposure an elevation of 212 feet. At the abandoned mine on the S. A. L. Railway about 7 miles east of River Junction the fullers earth, upper stratum, lies 177 feet above sea level. At Quincy 20 miles east of River Junction the top of the upper stratum of fullers earth is 145 feet above sea. Continuing this line of levels, it is found that an exposure of fullers earth about 1 mile east of Little river is at the level of 120 feet above sea. At the fullers earth mine at Midway, the elevation of the top surface of the fullers earth is 112 feet above sea. The dip of the formation in the direction of this line of levels which is slightly south of east from River Junction is about 100 feet in 25 miles or an average of approximately 4 feet per mile. From northwest to southeast, as measured from River Junction to Jackson Bluff, the dip in the formation is somewhat greater, approximating 5½ feet per mile, or 137 feet in a distance of about 25 miles.

At Attapulgus the fullers earth stratum lies 173 feet above sea. From this locality to Midway, a distance of about 19 miles, the dip in the formation is 59 feet. The average rate of dip in this direction, which is approximately from north to south, is therefore about 3 feet per mile. Near Sopchoppy river, clays resembling the fullers earth lie in this formation at an elevation of 23 feet above tide water. If the line of elevation be extended from Attapulgus

to Sopchoppy the whole dip amounts to 150 feet in a distance of about 50 miles, or an average of 3 feet per mile. Levels on the fullers earth horizon of this formation are given on the sketch map, figure 3.

THE CHOCTAWHATCHEE FORMATION.

The Choctawhatchee formation, which is of upper Miocene age, includes marine shell marls and marine sands. The type locality of this formation is at Alum Bluff on the Apalachicola river. The fossiliferous shell marl of the Choctawhatchee formation in this bluff has a thickness of from 14 to 19 feet. The shell marl grades above into blue sandy clay which varies in thickness in this bluff from about 16 to 26 feet. The clay contains small flakes of mica, and in places tastes of alum. The Choctawhatchee formation at this exposure rests unconformably upon the Alum Bluff formation.

At the east side of this area the Choctawhatchee marl is well shown in the exposure at Jackson Bluff. The following section at this bluff was made by the writers in March, 1918. The water level in the river at the time this section was made was 27.7 feet below the floor level at the center of the supporting arch of the public road bridge. The section was measured by hand level.

SECTION AT JACKSON BLUFF.

6.	Sands, rather coarse, in places dark colored	15.1	feet
5.	Choctawhatchee shell marl, maximum thickness	16.5	feet
4.	Heavy buff-colored clay, resembling fullers earth	1.4	feet
3.	Sandstone, coarse grained	2.0	feet
2.	Heavy buff-colored clay, resembling fullers earth	3.6	feet
1.	Sands, calcareous and slightly phosphatic, few fossils	22.1	feet
		60.7	feet

Numbers 1 to 4 of this section represent the Alum Bluff formation. The two fullers earth layers with the intervening sandstone are represented apparently by 2 to 4. The shell marl phase of the Choctawhatchee formation is represented by number 5. The top surface of this shell marl is irregular, and the overlying aluminous clay is wanting. Whether this irregularity represents an uncon-

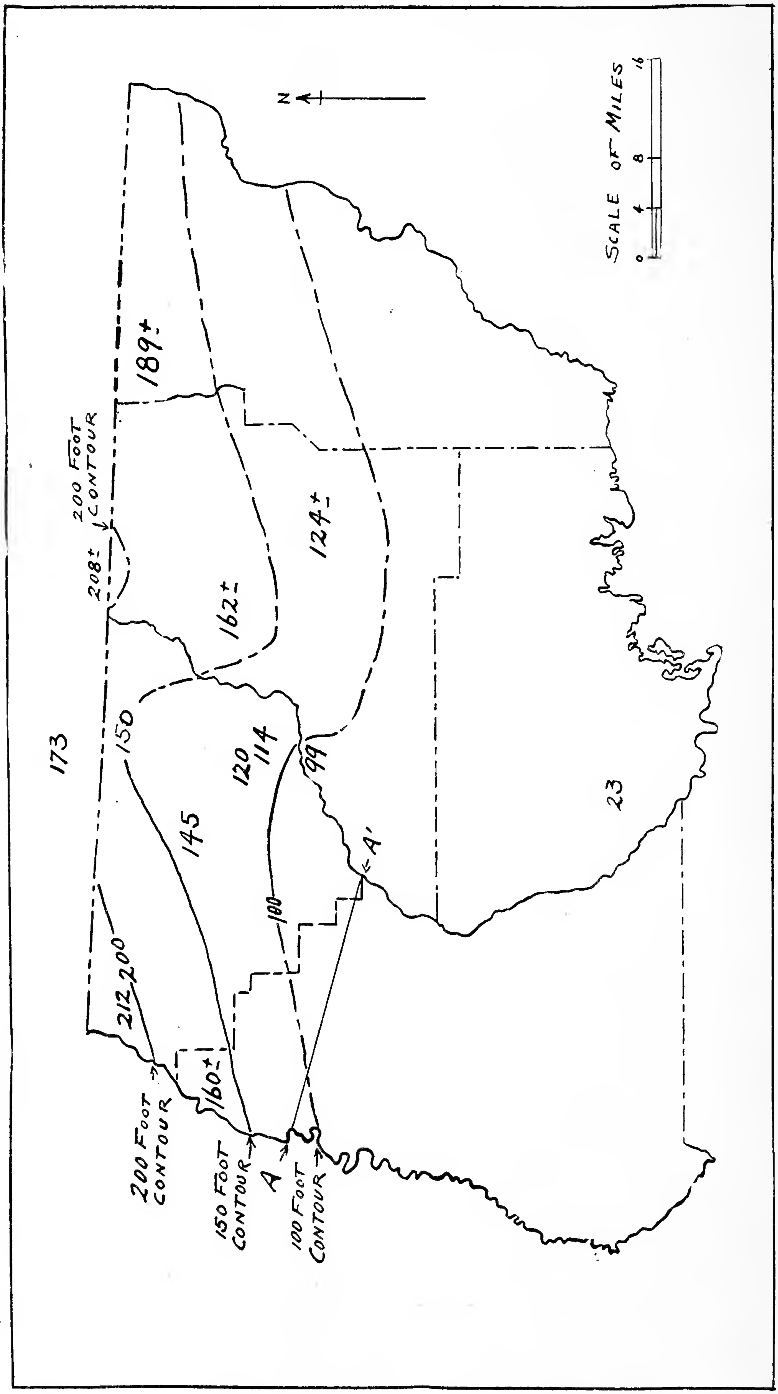

Fig. 4. Contours on the fullers earth horizon of the Alum Bluff formation. Elevations marked by the "plus-minus" sign are inferred levels. AA' indicates the line of approximately uniform levels on the Choctawhatchee formation, which apparently does not conform in structure to the Alum Bluff and Chattahoochee formations.

formity between this formation and the overlying sands, or is due merely to disintegration is not clear in this section, although an unconformity is probably indicated. The Choctawhatchee formation rests unconformably on the underlying Alum Bluff formation.

The shell marl phase of the Choctawhatchee formation contains a rich and varied invertebrate fauna. No plant fossils have been found in this formation. Bone fragments are not uncommon, although no recognizable vertebrate fossils have been secured.

STRUCTURE.

The level of the base of the Choctawhatchee marl has been taken at several localities. On the Apalachicola river the northernmost exposure of the shell marl phase of the formation that has been observed is found in the road-cut leading to Watsons Landing about 2 miles north of Alum Bluff (S1, T1N, R8W). The base of the formation at this place was found to be 56 feet above water level in the river. The water level in the river at this place at the time the section was made, was estimated to be 41 feet above sea level. Hence the actual level of the base of the formation at this exposure is about 27 feet above sea.

At Alum Bluff the water level in the river was estimated from the known levels at River Junction and at Blountstown to be 40 feet above sea. Near the north end of this bluff the base of the Choctawhatchee marl is 36 feet above the water in the river, or about 76 feet above sea. Near the middle of the bluff the base of this formation is above water 30 feet, or above sea level about 70 feet.

The southernmost exposure of this formation observed on the Apalachicola river is on the property of S. D. Johnson (S.36, T1S, R8W). The base of the shell marl at this exposure is 22 feet above water level in the river. The water level in the river at this date at Blountstown was 35 feet above sea. As this locality is down stream from Blountstown about 6 miles, the river level probably is between 3 and 4 feet lower than at Blountstown, or about 31 feet above sea. The level of the base of the formation at this place is therefore about 53 feet above sea. The distance in a direct line between Watsons Landing and Johnson's farm is about 10 miles. The dip in the formation in this distance according to

the measurements made amounts to 23 feet, or scarcely 2 1-3 feet per mile.

The Choctawhatchee marl is exposed on Hosford Mill creek on the property of R. F. Hosford about 1½ miles northwest of the present Hosford station. The level of the marl at this exposure as determined from the profile of the Apalachicola Northern railroad is 88 feet above sea. It is not known what part of the stratum is represented in the Hosford exposure since neither the base nor the top of the formation is exposed. No nearby bench marks are available from which to determine the level of the exposures of this formation on the Ocklocknee river. However, the water level at the S. A. L. crossing at medium low water is about 60 feet above sea. From this crossing to the gulf, following the general course of the river, is about 45 miles, indicating a fall of somewhat more than a foot per mile. From this crossing to Jackson Bluff is about 15 miles. Hence water level at this bluff is probably close to 40 feet above sea. The base of the Choctawhatchee formation at Jackson Bluff is 29 feet above the river at medium low stage. Assuming that the water level in the river is 40 feet above sea, the actual level of the base of the formation at this place is approximately 69 feet above sea, or but slightly less than at Alum Bluff. Jackson Bluff is 20 miles east and 5 miles south of Alum Bluff. From these records it would seem that the Choctawhatchee formation lies almost on a level from east to west across this area.

MIOCENE-PLIOCENE

Later deposits in this part of the State overlie and rest upon the Choctawhatchee formation. These deposits are unfossiliferous, and their age is not determined, except as indicated by their stratigraphic position, which shows them to be later than the Choctawhatchee formation. Lithologically these later deposits are very characteristic. They consist chiefly of sands and clays. The sands are prevailingly red in color, and vary from nicely laminated, fine sands to very coarse, often cross-bedded sands and pebbles. At places in these deposits are found layers of clay free from sand. These clay streaks are often variegated in color, including shades of pink and red, as well as blue and drab.

The maximum thickness of this material at any one exposure is found at Alum Bluff, where the sands lying above the Choctawhatchee formation, exclusive of the light-colored incoherent sands near the surface, reach a thickness of 53 feet.

The following section at Alum Bluff was made March 14, 1918. The place of the section in the bluff is at a landslide about one-eighth mile from the north end of the bluff:

4.	Light-colored, incoherent, fine sand	21.14 feet
3.	Prevailingly red sands. This interval includes the following: clayey sands at the top which stand vertical, 5.58 feet; coarse sands, sloping, 7.41 feet; very coarse sands, laminated, but slightly indurated, consisting of alternating light and brown layers, 12.9 feet; medium coarse sands, white and brown layers, 12.64 feet; largely covered, sloping, but consisting as seen elsewhere in the bluff chiefly of dull red, medium fine sands, 24.65 feet. Total thickness	53.13 feet
2.	Choctawhatchee formation, consisting of alum-tasting, micaceous, drab, sandy clay, 16.4 feet; very fossiliferous shell marl, 14.85 feet. Total thickness	31.25 feet
1.	Alum Bluff formation, including calcareous and phosphatic sands, 11.7 feet, and a covered, sloping interval, which consists as seen elsewhere in the bluff of sands and Chipola shell marl, 18.07 feet. Total thickness	29.77 feet
Total height of bluff		146.56 feet

The change in color in passing from the Choctawhatchee formation to these overlying deposits is abrupt, and the line well marked. The change in the materials of the formation, however, is not so well marked. The upper part of the Choctawhatchee formation consists of drab-colored, sandy clays, which weather on exposure to a dull or slightly brownish color. The immediately overlying material consists of rather fine, dull red sands or sandy clay, which, aside from color, are not entirely unlike the weathered product of the Choctawhatchee formation. The contact line is exposed at several places in this bluff. Near the north end of the bluff the dividing line between the red sand and the drab, sandy clay is 66.8 feet above water level. At an exposure a little farther south the dividing line is at 63.2 feet above the river, while at the place in the bluff where the section given on the preceding page was measured, the dividing line appears to lie 61 feet above the river. Near the south end of the bluff the aluminous clay of the

Choctawhatchee formation rises to a level of about 73 feet above water level in the river at this stage. The two formations may be unconformable at this exposure, since the top of the Choctawhatchee formation near the south end of the bluff is apparently as much as 10 feet higher than at the north end of the bluff.

To the north of Alum Bluff this formation extends beyond the known limits of the Choctawhatchee marl, overlapping upon the Alum Bluff formation. To the south and east, the deposits may be recognized in numerous exposures. At all places where examined the deposit has been found to be non-fossiliferous, and when this formation rests directly upon the cross-bedded sands of the upper part of the Alum Bluff formation, it becomes difficult in the absence of fossils to locate the dividing line between the two formations.

This formation is exposed in a steephead on the property of J. H. Hunt, 1 mile south of Bristol. Near the surface at this place is found 10 feet of clayey, mottled sand, sufficiently indurated to stand vertical. Beneath this sand is 4 feet of drab-colored, heavy clay. Below the clay, the sides of the steephead are sloping and covered, but probably include slightly indurated sands. Springs emerge at the bottom of the steephead, which has a depth of about 50 feet. The surface level at this locality, as indicated by approximate levels, is probably about 150 feet above sea. The actual elevation of this formation as seen at this exposure is therefore from about 100 to 150 feet above sea. At Alum Bluff, 3 miles farther north, the formation, as already noted, occupies the interval from 101 to 154 feet above sea.

This formation is also exposed in the bluffs bordering Mystic lake, about 3 miles south of Bristol. This lake, which has no surface outlet, evidently owes its existence to the presence of the underlying calcareous marls of the Choctawhatchee and probably of the Alum Bluff formations which have dissolved, permitting the subsidence which thus formed the lake basin.

At the S. D. Johnson place (S26, T1S, R8W), about 75 feet, chiefly sands, overlie the Choctawhatchee shell marl. At Hosford Mill creek, 12 miles east of Alum Bluff, 40 or 50 feet of sands and sandy clays lie above the Choctawhatchee formation.

To the north from Alum Bluff, this formation is frequently exposed in streams and in steepheads. Near the head-waters of Big

Sweetwater creek, about 3 miles southeast of Rock Bluff postoffice (S33, T2N, R6W), about 80 feet of sands overlie the Choctawhatchee marl. The exposure here is limited, and the top of the Choctawhatchee formation cannot be determined, as the hill is sloping and covered. This exposure is the last in passing to the north and northeast, at which the Choctawhatchee marl is known to be present beneath this later formation. Farther to the north, so far as known, the Choctawhatchee formation is wanting, the later materials resting directly upon the Alum Bluff formation.

A very instructive section, a part of which is referred to this formation, is found in a steephead about 1 mile southeast of Rock Bluff. In this section the red sands and clays rest directly upon the Alum Bluff formation, the Choctawhatchee formation being absent. The actual contact between the two formations, however, is concealed.

The following section is a revision of the section at this place made by the writers in 1908. From barometer readings, the top of the section at that time was believed to be about 200 feet above water level in the river. However, from levels made in March, 1918, it is shown that the top of the section is 225 feet above the level of the river, or about 267 feet above sea level.

SECTION ABOUT 1 MILE SOUTHEAST OF ROCK BLUFF.

11.	Superficial sand, sloping (about)	5 feet
10.	Reddish, coarse sand, "Alamaha Grit" phase. The surface of the ground near the brink of the cliff is profusely covered with iron concretions, remaining as residual material from the decay of the formation. The first 1 to 4 feet of the sand is discolored and mottled and shows a tendency to the formation of iron stained crusts. Iron concretions occur in the sand from the surface to a depth of seven feet. These show a tendency towards arrangement in layers. One such layer is observed to extend from the mottled and decayed surface material downwards and horizontally into material apparently not appreciably affected by decay. The sand is usually cross-bedded, containing white siliceous pebbles. Near the base the sands are finer than in the upper part of the interval	52 feet
9.	Sandy yellowish laminated clays giving rise to small springs	2 feet
8.	Pink clays, free from sand and very plastic	2 feet
7.	Yellow sandy clays	3 feet

6.	White water-worn, elongated siliceous pebbles imbedded in yellow sandy clays and lying with long axis parallel with the lines of stratification	1 foot
5.	Yellow clayey sand	7 feet
4.	Greenish, sticky, sandy clay	9 feet
3.	Covered and sloping (about)	44 feet
2.	Alum Bluff formation, including intensely blue sands and calcareous and phosphatic sands	20 feet
1.	Covered in this section from the Apalachicola River, including the upper part of the Chattahoochee formation and the lower part of the Alum Bluff formation (about)	80 feet

The Choctawhatchee formation is not recognized in this section, and is not present, unless possibly in a somewhat modified form. The contact between the Alum Bluff formation and the later materials is possibly within the covered interval, No. 3 of the section.

In the section at Aspalaga Bluff, the covered interval of 60 feet at the top may, in part, include this formation. In the section at Chattahoochee Landing, it would seem admissible to refer Nos. 11 and 12, including 37 feet of pinkish clay and red sands to this formation. The contact at the Chattahoochee Landing between the Alum Bluff formation and the overlying formation is presumably found within the covered interval of 42 feet, No. 10 in the section. If this interpretation is correct, the formation in question is traceable to the Georgia-Florida State line.

To the east from the Apalachicola river, many exposures are found in the streams and public road and railroad cuts showing cross-bedded red sands which may be of this formation. In passing from River Junction to the plateau level in Gadsden county, both the Apalachicola Northern and the Seaboard Air Line railways, which utilize the valley of Mosquito creek, afford exposures of these red sands. The following section was obtained by following the course of the Apalachicola Northern railroad from Mosquito creek to the plateau level near Hardaway. The base of this section, as determined from the profile of the Apalachicola Northern railway, is 120 feet above sea, and the top is 303 feet above sea. The top of the Alum Bluff formation presumably is found in the covered interval, No. 3 of this section, hence at an elevation above sea of 184 feet or more.

SECTION ON A. N. RAILWAY FROM MOSQUITO CREEK TO HARDAWAY.

8.	White incoherent sand and soil	5 feet
7.	Red and mottled sands	10 feet
6.	Dark colored sandy clay, including layers of pink and purple clays	10 feet
5.	Covered in this section, or showing only reddish sands	45 feet
4.	Cross-bedded sands with white partings, including stratum of blue sticky clay	21 feet
3.	Covered, or showing only red sands	28 feet
2.	Alum Bluff formation, including fullers earth beds, gray marls weathering to greenish clays, containing silicified oysters, and light colored sandy marls (occasional exposures)	64 feet
1.	Light colored limestone rock, probably Chattahoochee formation tion (exposed at the base of this section)	

Many exposures of these red sands are found in and near Quincy. The following section is seen at the public road crossing of the Seaboard Air Line railway 3 miles east of Quincy, a short distance west of mile post 186. The elevation at the base of this section is 220 feet above sea.

5.	Yellow soil with iron pebble concretions	3½ feet
4.	Pink-colored sandy clay	3 feet
3.	Massive red sands	4½ feet
2.	Red sands with white partings	5 feet
1.	Massive red sands	4½ feet
		20½ feet

At Quincy approximately 100 feet, consisting chiefly of sands and sandy clays, lie above the fullers earth. The contact between the Alum Bluff formation and this overlying material is concealed, or at least is not apparent. Good exposures are seen on the public road and on the branch line of the Seaboard Air Line railway running to the fullers earth plant. In Leon county, east of this area, are many exposures which possibly should be referred to this formation, although they have heretofore been included with the Alum Bluff formation. These exposures in Leon county have been described in the preceding report of this Survey, pp. 104-108, 1917.

FORMATION NAME.

The differentiation of the superficial formations has proven one of the most difficult problems in coastal plains geology. That this is true is evident from the number of formation names that have been proposed and abandoned or subsequently restricted, as well as by the voluminous discussion that this subject has given rise to. The Lafayette formation was formerly believed to be very extensively developed in the coastal plains. In recent years, however, it has been maintained by a number of geologists that superficial materials from several different formations have been included under this term. In 1884 Loughridge described materials in Georgia to which Dall in 1892 applied the term Altamaha Grit. These materials were more fully described under the term Altamaha formation by Veatch in 1908* and by Stephenson and Veatch in 1911.† At this time Stephenson and Veatch recognized that the materials referred to this formation, extending over about 21,000 square miles of Georgia from the Savannah river to the Florida State line, possibly contained parts of various formations. Subsequently, these writers expressed the conclusion that the greater part of the materials referred to the Altamaha grits belonged to the Alum Bluff formation or to other Cretaceous and Tertiary formations.‡ In 1916 Matson and Berry described the Citronelle formation, the tpye locality of which is in Alabama.§ This formation which is of Pliocene age, is regarded as extending into the western part of Florida. Matson has suggested that possibly the red sands in the section at Alum Bluff represent this formation.

The red and mottled sands and sandy clays of this area are in places similar to those that have been referred to the Lafayette formation, elsewhere it resembles that which formerly was placed in the Altamaha formation of Georgia. If Altamaha is retained as a formation name, restricted if necessary to the deposits consisting chiefly of red sands and clays lying above the Miocene, it is very pos-

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* Science, n. s. Vol. 27, Jan., 1908, pp. 71-74.

†Geol. Surv. Ga. Rpt. 26, pp. 400-423, 1911.

‡U. S. G. S. Water Supply Paper, 341, p. 94, 1915.

§The Pliocene Citronelle formation of the Gulf Coastal Plain; U. S. Geol. Survey, Prof. Paper 98, pp. 167-192, 12 pls., 3 fig., September 11, 1916. Abstract, Washington Acad. Sci., Journ., Vol. 6, No. 19, p. 663, November 19, 1916.

sible that the similar materials of this area may be included in that formation. If not referable to the Altamaha formation, possibly these materials may be referred to the Citronelle formation, although this should not be done until fossils can be obtained or continuity of deposition with the Citronelle formation can be determined. If these materials can be referred to neither of these formations, they may be known as the Bristol formation from their typical exposure in the vicinity of Bristol, Florida, where they are known to lie stratigraphically above the Choctawhatchee Miocene.

STRUCTURE.

A study of the structure of this formation is made difficult by the fact that only occasionally can the base of the formation be located. Approximate levels indicate, however, that the deposits dip to the south. At Alum Bluff, as already noted, the base of this formation is 61 feet above water level, or about 101 feet above sea. At Rock Bluff the base of the formation, assuming that it extends to the north, cannot be less than 100 feet above water level, or about 142 feet above sea. At Chattahoochee Landing, materials referred to the Alum Bluff formation were exposed at the time the published section was made, to a level of 103 feet above the river, or about 154 feet above sea, above this being covered. Recently the cut on the public road has been deepened, and exposures of the Alum Bluff formation may now be recognized up to an elevation of 121 feet above the river, or 172 feet above sea. If this formation is present in this section, therefore, it lies at a greater elevation than 172 feet above sea. On the public road one mile southeast of River Junction the fullers earth horizon is exposed at 212 feet above sea.

At Hosford, 12 miles east of Alum Bluff, where the red sands of this formation lie above the Choctawhatchee marl, the base of the formation, as seen in the railroad cuts, appears to lie about 110 feet above sea.

From such approximate elevations on this formation as have been obtained it appears that the formation dips to the south, the rate of dip being approximately the same as that of the underlying formation.

PLIOCENE.

Marine Pliocene deposits have not been definitely determined, although limestone found on New River in Franklin county may be of this period. A small collection of fossils from this rock has been kindly identified for the Florida Geological Survey by Dr. T. W. Vaughan of the U. S. Geological Survey. The fauna from this deposit, as reported by Dr. Vaughan, include the following:

Pecten comparilis, Tuomey & Holmes; Range, Miocene.
Pecten mortoni, Ravenel; Range, Miocene-Pliocene.
Pecten raveneli, Dall.; Range, Miocene-Pliocene.
Plecatula marginata, Say; Range, Miocene-Pliocene.
Pecten sp.
Ostrea sp.
Bryozoa.
Barnacles.
Correlation: Miocene or Pliocene.

The stratigraphic position of these limestones suggests that they are probably Miocene.

PLEISTOCENE.

No marine fossiliferous Pleistocene has been found in this area. The harbors of the westward extension of Florida are regarded as representing the flooded mouths of stream valleys. If this is true, the submergence which produced these harbors has possibly concealed the fossiliferous Pleistocene of this part of the coast.

THE SURFACE MATERIALS.

The surface materials in this area include, in places, a considerable thickness of light-colored incoherent sands. The maximum observed deposit of this sand is found in the Alum Bluff section, where it is 21 feet thick. The sand grains are, as a rule, small and well rounded. On the east side of the Apalachicola river a belt of this sand extends from near Rock Bluff to Bristol, a distance of 8 or 10 miles. Both north and south of this belt there is much less sand at the surface. On the line of the Apalachicola railway this sand belt extends from about 1 mile north of Sedalia to near Hos-

ford, a distance of 8 miles. On the line of the Georgia, Florida and Alabama railway the belt of heavy sands extends from 2 miles south of Tallahassee to Wakulla county line, having here a width of 8 or 9 miles.

The location and direction of this belt of sand, extending from slightly north of west to somewhat south of east, suggests that it may represent either a beach deposit or the outcropping of a very sandy horizon of the underlying formation.

Loose surface sands are found in many other places within this area under conditions that seem to indicate that they are residual. In many instances the sand has, no doubt, been moved more or less by wind or by stream action.* On slopes where surface wash is pronounced, these loose sands are wanting, as they are removed as rapidly as formed. On the other hand, on level lands the sand often accumulates to a considerable depth.

GEOLOGIC HISTORY.

The geologic history recorded in this area, as already noted, is that from the Oligocene time to the Recent. During the later part of Oligocene time, if the Chattahoochee formation is correctly referred to that period, this part of Florida as well as parts of Georgia, was submerged beneath a sea of moderate depth. The deposits that accumulated in this sea, making up the Chattahoochee formation, were chiefly calcareous, although in addition to the calcareous material there was included a very considerable proportion of fine clay carried in from the land. Relatively little sand was washed into this formation, which indicates either that the shore line was some distance away or that the currents were very mild.

The change in conditions in passing from the Oligocene to the Miocene in this area were gradual. The predominately calcareous materials of the Chattahoochee formation give place gradually to the sandy calcareous materials of the Alum Bluff formation. During the period of accumulation of the Alum Bluff formation, lower and middle Miocene, the shore line was much nearer. In the type

* In the railway cut at Lowry, on the Apalachicola Northern Railway, there is exposed, about 4 feet below the present surface, an old swamp deposit with many tree stumps in place. This swamp had been obliterated by the shifting of the sands, and there was on the surface at this place no evidence of a swamp, the swamp growth having been replaced by "scrub" vegetation.

exposure of this formation there is evidence of contemporaneous erosion probably by stream wash. Land plants likewise were included in considerable numbers indicating that the shore line at that time was near to this locality. The presence of land vertebrates at places in this formation indicates also the near approach of land.

Between the deposition of the Alum Bluff Miocene and the Choctawhatchee Miocene is a time interval, evidence of which is found in the eroded top surface of the Alum Bluff formation. This erosion interval indicates that following the deposition of the Alum Bluff formation this area became dry land. Subsequently the land was again depressed and partly submerged. That the submergence during the time of the deposition of the Choctawhatchee formation was not complete is shown by the fact that this formation does not cover the whole of the area, but extends inland only to near the southern line of Gadsden county.

The Choctawhatchee formation was followed, as has been stated, by the accumulation of a considerable thickness of sands and sandy clays. These later deposits are cross-bedded, include in places beds of gravel and coarse sands indicating that they were accumulated in strong currents, either of fresh water streams, or in near-shore marine currents.

SUMMARY OF GEOLOGIC STRUCTURE.

The data that have been obtained on the structure in this area have shown the existence of minor folds, especially in the limestones, but have not indicated the presence of any pronounced anticlines such as would suggest favorable structure for the accumulation of petroleum deposits. The dip of the formations in the main is to the south, or southeast, and is more rapid than the gradient or fall of larger streams, so that in passing inland from the coast, successively older formations are encountered. The average rate of dip of the Chattahoochee formation on the Apalachicola river from north-northeast to south-southwest has been shown to be about 7 feet per mile. The dip in this formation from west-northwest to east-southeast appears not to be in excess of 4 feet per mile. The rate of dip of the Alum Bluff formation across this area from north to south has been shown to be about 3 feet per mile. The maximum dip of the Alum Bluff formation in this area is probably from northwest to southeast, and is about 5½ feet per mile.

The Choctawhatchee formation which rests unconformably upon the Alum Bluff formation dips very gradually to the south, probably not in excess of 2 1-3 feet per mile. The red sands and clays lying above the Choctawhatchee formation conform so far as can be determined essentially to the structure of the underlying formation dipping gradually in passing to the coast. To the north these red sands extend beyond the limits of the Choctawhatchee formation and rest directly upon the sands of the Alum Bluff formation.

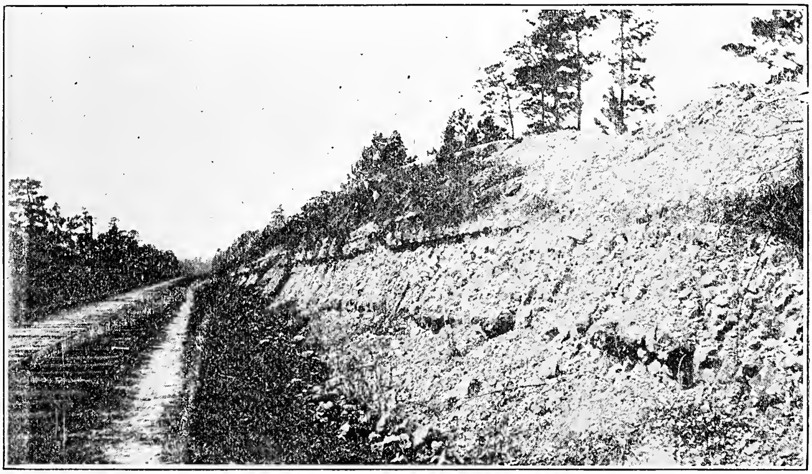


Fig. 5. Exposure of the Chattahoochee formation in railway cut near River Junction.

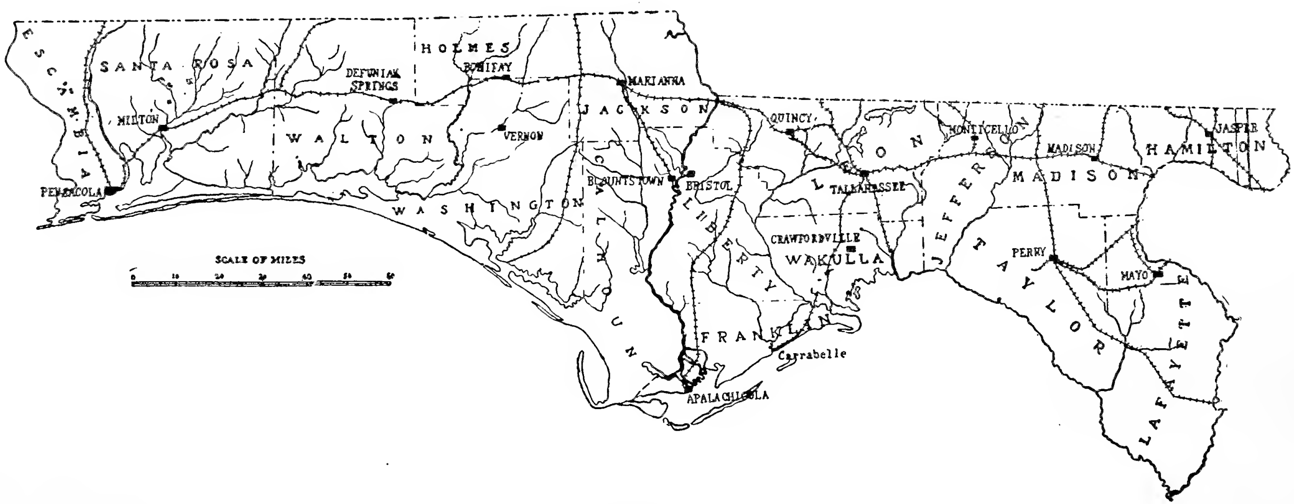


Fig. 6. Sketch map of West Florida.

THE SKULL OF A PLEISTOCENE TAPIR INCLUDING DESCRIPTION OF A NEW SPECIES AND A NOTE ON THE ASSOCIATED FAUNA AND FLORA.

E. H. SELLARDS.

CONTENTS.

The tapir skull described in this paper was obtained from Pleistocene deposits at Vero, Florida. It it exceptionally well preserved and, with some other bones and teeth from the same locality, represents an undescribed species. The skull was discovered by Mr. Frank Ayres and was removed from the formation by Mr. Ayres, the writer and others. This fossil was found near the base of the stratum or horizon, which in the published section of this exposure has been designated as No. 2.* Beneath this stratum is found a sand and muck bed, No. 3 of the section. The fairly complete knowledge that we now have of the associated invertebrate, vertebrate and plant fossils at this locality adds to the interest which attaches to this new species. Moreover, while tapirs are known to have been rather widely distributed during the Pleistocene period, up to this time no well preserved skull has been secured. The recovery of this skull, therefore, is of great importance, since the actual relationship of the Pleistocene species to the recent forms has been until now in doubt. The skull was found on the day following the close of the conference of geologists and anthropologists held at Vero in October, 1916. It became exposed owing to high waters

* Fla. Geol. Survey, 8th Ann. Rpt., pp. 127-130, 1916.

in the canal following the heavy rains in this locality of October 28, 1916.

THE TAPIRIDAE.

The Tapiridae as a whole have proven a conservative as well as very persistent group. Genera referred to this family have been obtained from as early as the Eocene and Oligocene formations of America and Europe. The striking characteristics of the tapirs, very pronounced in the case of the Recent and Quaternary species, are the modifications of the skull correlated with the development of the upper lip to form a flexible snout or proboscis. The skull modifications include the extreme shortening of the nasal bones, which, with the deep spiral grooves on the nasals and frontals for the attachment of the muscles of the proboscis, form the most strikingly distinctive skull characters of this remarkable family. The dental series, although relatively simple and generalized, presents in the Recent and Quaternary species the anomaly of enlarged upper third incisors, which, with the lower canines, form tusks, the upper canines being reduced in size.

The existing tapirs include five species. Of these, two species are found in Central or Middle America; two in South America; and one in Southern Asia. Upon characters presented by the two Middle American species, Gill in 1865 established the genus *Elasmognathus*.* This genus is characterized by a great prolongation of the ossification of the nasal partitions (methesmoid), extending in the adult far in front of the nasal bones. The bony mass thus formed is embraced and supported at the base by plates rising from the maxillaries. The generic name *Elasmognathus* being preoccupied, Palmer, in 1903, proposed for this group the name *Tapirella*.† The two recent species of this genus are *Tapirella bairdii*, found in Southern Mexico and Panama, and *T. dowi*, found in Guatemala and Nicaragua. The remaining three existing species of tapirs are placed in the genus *Tapirus*, in which the ossification of the nasal partition does not extend appreciably beyond the nasal bones, and in which there is no ascending plate from the maxillaries. The species of this genus are *Tapirus terrestris* and *T. roulini* of South America and *T. indicus* of Malay, Sumatra and Borneo.

* Proc. Acad. Nat. Scien. Phil., 1865, p. 185.
†Science, Vol. 17, p. 873, May 1903.

Of Pleistocene tapirs only a few species are known although the few specimens recovered indicate a wide geographical distribution for the family. As early as 1860 Leidy described a tapir from the Pleistocene of Kentucky, and assigned to it the specific name *Tapirus haysii*.* This species has since been recognized at a number of localities in the eastern part of the United States. A sub-species, *T. haysii californicus*, has been described by Merriam from the Auriferous Gravels of California.† A tapir smaller than *T. haysii*, found fossil at many localities in the eastern part of the United States has been commonly referred to the existing South American species *T. terrestris*. This identification, however, always doubtful, is probably incorrect as indicated by the fossil described in the present paper. The tapirs reached South America as early at least as the Pleistocene, two or three species having been recognized by Lund in the cavern deposits of Brazil. From the Pleistocene of China a tapir is reported which has been described as *Tapirus sinensis*.‡

Of the North American Pleistocene tapirs *T. haysii*, particularly the sub-species *T. haysii californicus*, presents according to Merriam, so far as can be determined by tooth characters, a closer relationship to *Tapirella* (*Elasmognathus*) *bairdii* than to any other recent species. The new species described in this paper finds its place as shown by the skull characters, in the genus *Tapirus*.

SKULL OF THE PLEISTOCENE TAPIR.

The skull obtained at Vero is that of a mature individual. All the permanent teeth had come into use, although fortunately for the purposes of study of tooth structure, they are but slightly worn. The lower jaws are wanting. However, the Survey collection contains parts of the lower jaws of other individuals from the same locality, as well as numerous detached upper and lower teeth.

* Holmes's Post-Pliocene Fossils of South Carolina, p. 106, pl. 17, Figs. 4, 7-10, 1860.

†Tapir Remains from Late Cenozoic Beds of the Pacific Coast Region Univ. Cal. Pub., Vol. 7, pp. 169-175, 1913.

‡Schlosser, M., Die fossilen Saugethiere Chinas nebst einer Odentographie der recenten Antilopen. Abh. k. bayer. Akad. Wiss., cl, ii, Vol. xxii, Pt. 1, Munich, 1913.

The skulls of recent tapirs with which the fossil tapir is here compared are contained in the collection of the U. S. National Museum. For the privilege of consulting this collection of skulls the writer is indebted to the officials of the Museum. For the measurements on the skull of *Tapirella dowi* as well as some supplementary measurements of some of the other skulls the writer is indebted to the kindness of Dr. O. P. Hay. In selecting skulls for comparative measurements, those of mature individuals have been used. The only exception is in the skull of *T. roulini,* which is from a scarcely mature animal. The tapir skulls used in these measurements are the following, all of which are in the National Museum collection: *Tapirus indicus,* No. 14648; *T. terrestris,* No. 198; *T. roulini,* No. 12759; *Tapirella bairdii.* No. 13486; *T. dowi,* No. 11282.

In generic and family characters the skull of the Pleistocene tapir is in agreement with that of modern tapirs. The nasal bones are placed equally as far back on the skull; the spiral grooves, although shallow, are broad and well marked; and the third incisor is enlarged at the expense of the canine. The proboscis as indicated by these skull characters was well developed.

Although agreeing in these general features, the skull of this Pleistocene species is found to present many differences from that of any one of the living species. In side view the skull is noticeably flat topped, the nasals lying approximately in a plane with the top of the skull. The sagittal crest is but slightly developed, being represented by a slight ridge bounded by two raised lines. The sides of the cranium are full and well rounded. The occipital crest is pronounced, and the lambdoidal ridges widely separated. The spiral groove is broad and shallow, much of it being on the nasals. The lachrymal bone is large and rises almost vertically, in side view obscuring the nasal process of the maxillaries. A lachrymal pit is present. The palate is arched in transverse section, and is relatively deep, exceeding in depth that of the recent species by several millimeters. The posterior narial opening narrows backward, while in all recent species this opening widens backward.

In these skull characters this Pleistocene species differs more or less from all of the existing tapirs. The immature individuals of the modern species have flat topped skulls, with but slight development of the crest, although in the adult stage a crest is present, and

the cranium is more or less arched. The crest in the adult *Tapirus indicus* forms a broad ridge. A rather more pronounced sagittal crest is found in mature individuals of *Tapirella bairdii.* The maximum development of the sagittal crest among tapirs is found in the skull of old individuals of *Tapirus terrestris.* In this species the crest becomes very pronounced and the cranium is arched, and rises at the center much above the plane of the nasal bones. In *T. terrestris,* in particular, the development of the crest would seem to be at the expense of brain capacity. The sides of the skull below the crest in this species are contracted, and actually become concave in rising to the crest. The crest of the modern species, together with the contracted sides of the skull affords a greatly increased space for attachment of the muscles of mastication.

Important differences are found in the proportionate development of the facial and cranial parts of the skull. The Pleistocene tapir has a relatively shorter face than has any one of the modern species. This difference, apparent upon inspection, is brought out more definitely by measurements as shown in the tables given below.

In the following table the length of the skull on the median line is given in column 1; the length of the face from the nasal-frontal suture to the anterior tip of the premaxillaries in column 2; the measurement from the posterior margin of the hard palate to the tip of the snout in column 3. The proportionate length of the face as compared to the whole length of the skull on the mid-line is given in column 4. In column 5 is given the proportionate length of the hard palate as compared to the whole skull.

	1. Length of skull (cm.)	2. Length of face (cm.)	3. Length of palate	4. Pro. face to skull (%)	5. Pro. pal. to skull (%)
Florida Tapir	400 mm.	214 mm.	198 mm.	53.5	49.5
T. indicas	435 mm.	270 mm.	219 mm.	62	50.3
T. terrestris	366 mm.	205 mm.	187 mm.	56	51
T. roulini	350 mm.	190 mm.	183 mm.	54.2	52.2
Tapirella bairdii	435 mm.	305 mm.	232 mm.	70.1	53.3
T. dowi	422 mm.	289 mm.	227 mm.	68.4	53.7

The measurements just given indicate that the face of the modern tapirs, although varying in the different species, is, without

exception, proportionately longer than that of this Pleistocene species.

SPECIFIC DESCRIPTION.

TAPIRUS VEROENSIS N. SP.

Medium sized tapirs of the genus *Tapirus*. Spiral groove very broad, placed well upon the nasals; excavation of groove into frontals and molars slight. a Lachrymal pit present. Face proportionately short; snout short, molar-premolar series relatively extended; diastema reduced. Parastyle of upper cheek teeth large. Valley between the transverse crest blocked by a pronounced ridge which extends from the paracone backwards and slightly inwards to the wall of the metacone pillar. A similar ridge or crest extends from the posterior side of the metacone to the cingulum at the posterior margin of the tooth. Third molars of the upper jaws large.

Type specimen, skull from Pleistocene deposits at Vero, Florida. Paratypes, parts of lower jaw and teeth from same locality.

SKULL CHARACTERS.

The characters on which this species is referred to the genus *Tapirus* rather than to *Tapirella*, as already stated, are found in the skull. There is no evidence of the prolongation of the methesmoid in front of the nasals, and there is quite certainly no bony plate rising from the maxillaries to support this bone. The species is thus excluded from the genus *Tapirella*. On the other hand the skull presents the essential characters of the genus *Tapirus*, to which accordingly the species is referred. The presence of a lachrymal pit, already noted, unless supported by other important skeletal characters, should not of itself exclude the species from the genus *Tapirus*.

DENTITION.

The upper molar and premolar teeth of the type specimen are perfectly preserved and but little worn. Of the incisors the enlarged third on either side is preserved, while the first and second incisors as well as the canines had dropped from the sockets previous to fossilization. A striking feature of the cheek teeth is the very large size of the parastyle, which in the molars, in particular, becomes a pillar closely appressed to the paracone which it approximately equals in size. On the exterior of the cheek teeth no

cingulum is observed, although between the paracone and metacone pillars there is a small tubercle and the suggestion of a cingulum which is best marked on the third and fourth premolar and on the first molar. At the inner side of the cheek teeth between the protocone and hypocone pillars is a strong tubercle which in the specimen at hand is particularly pronounced on the fourth premolar and on the third molar.

The molar teeth are larger than the premolars, the antero-posterior measurement of the three molars is 73 mm., while that of the four premolars is 76 mm. The molars may be recognized by their shape, being more nearly square than are the premolars. They may also be recognized by the very large size of the parastyle. The first molar is distinguished from those which follow by its smaller size as well as by the relatively small size of the tubercle between the paracone and hypocone pillars.

From the posterior side of the paracone of both molars and premolars a raised line or ridge passes to the anterior wall of the metacone, thus passing across and blocking the valley between the transverse crests. A similar raised line passes from the posterior side backwards and inwards and joins the cingulum of the posterior margin of the tooth. The paracone is supported on the inner side by a medium heavy buttress or ridge which passes to the floor of the valley between the crests.

In the lower jaw from the same locality which serves as a paratype there is preserved the third and fourth premolars and the first molar. The lower jaw, as judged from this part preserved, appears to have been relatively heavy and short. The height of the jaw is 50 mm; the width beneath the second molar is 33 mm. The molar tooth has a greater transverse width than the premolars, while the antero-posterior measurement is about the same as that of Pm_4. The molars are thus relatively broader than the premolar. Both molars and premolars have an anterior and posterior cingulum. On the outer margin the anterior cingulum is connected by a raised line with the protoconid. The transverse ridges are scarcely notched. At the inner side of the molar tooth a slight tubercle is developed between the anterior and posterior transverse crests. There is also a suggestion of a tubercle on the inner side of Pm_4. At the outer side of the teeth no tubercle is developed. Pm^2, lacking in this specimen, is represented by a detached tooth from the right side, No. 7026.

RELATIONSHIP TO OTHER PLEISTOCENE SPECIES.

Two species, as already noted, have been recognized in the Pleistocene of North America. These are *Tapirus haysii* and a smaller species commonly referred to the recent *Tapirus terrestris*. The type specimen of *Tapirus haysii* is a lower molar, probably the second, obtained from Big Bone Lick in Kentucky. This tooth is illustrated in Holmes Post Pliocene Fossils of South Carolina, pl. 17, figs. 7 and 8, 1860. It is preserved in the Philadelphia Academy of Sciences. According to Leidy this tooth measures 12½ by 10¼ lines or 26 by 21.3 mm. It is, therefore, a tooth from a large tapir. In addition Leidy referred to this species a part of a lower jaw from Mississippi and a lower molar tooth from Indiana, all representing a large species of tapir. Among other specimens subsequently referred to *Tapirus haysii*, the best preserved includes most of the upper and lower jaws from the Port Kennedy cave in Pennsylvania.

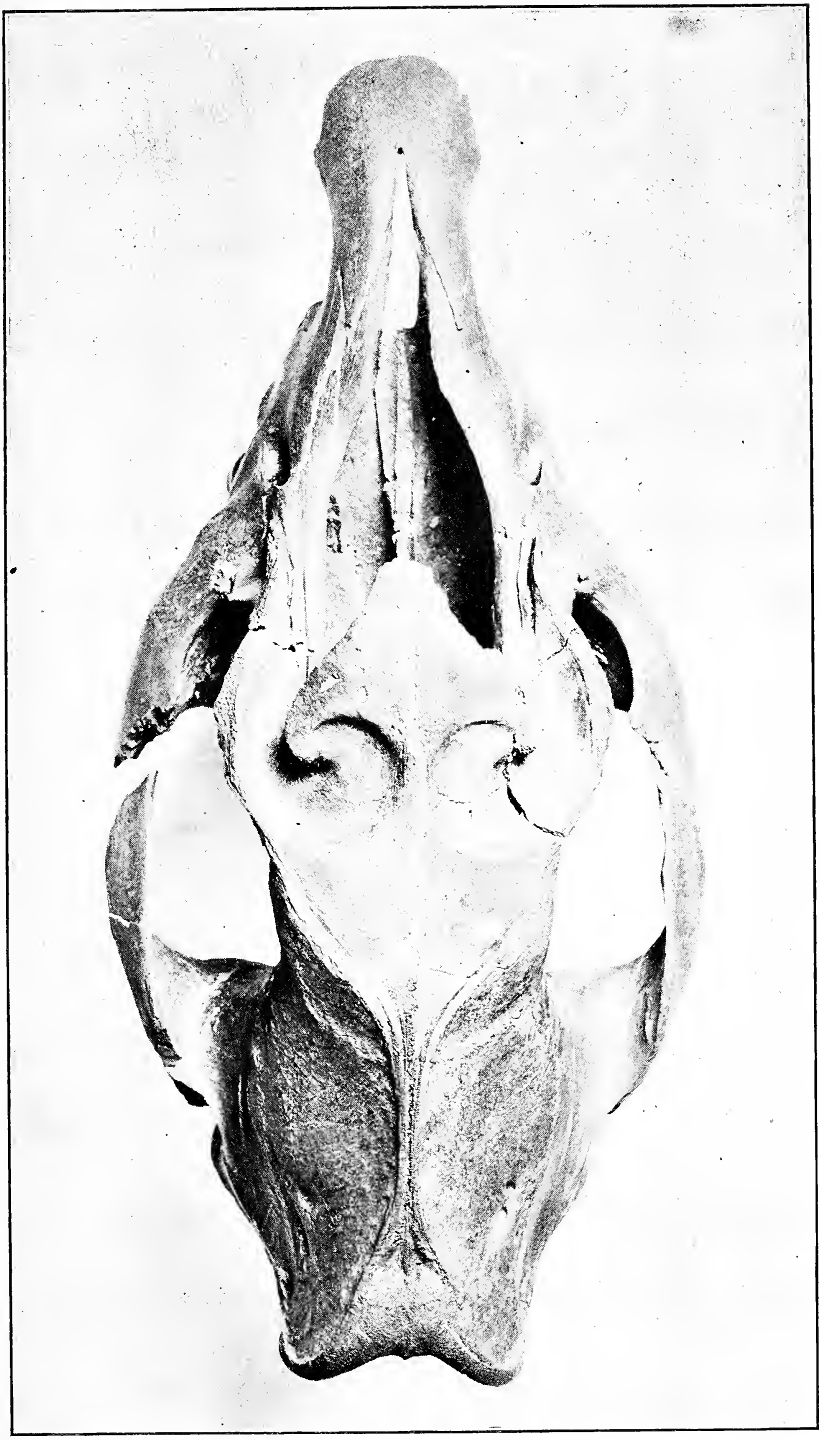
The Florida fossils represent a smaller tapir than those which have been referred to *Tapirus haysii*. This is indicated by the comparative measurements of the teeth, both of the lower molars as indicated by the type specimen of *Tapirus haysii*, and the upper molars are taken from specimens subsequently referred to that species. These measurements are given in the following tables:

MEASUREMENTS OF LOWER MOLAR TEETH.

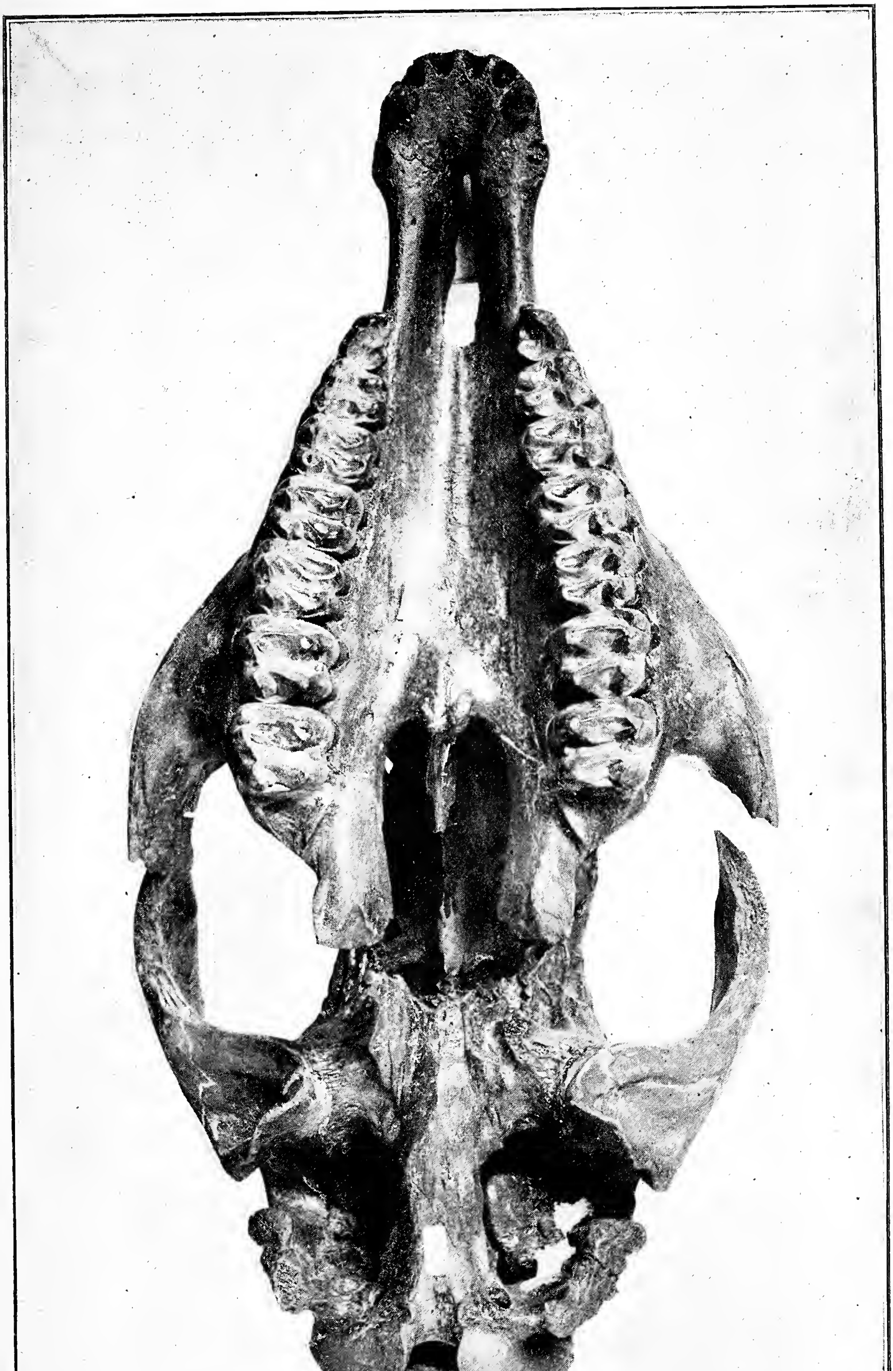
	T. haysii type	Fla. tapir	P. Kennedy
M_2 (?) anteroposterior	26 mm.		
transverse	21.3 mm.		
M_1, anteroposterior		23 mm.	29 mm.
transverse		18 mm.	21 mm.

MEASUREMENTS OF THE UPPER CHEEK TEETH.

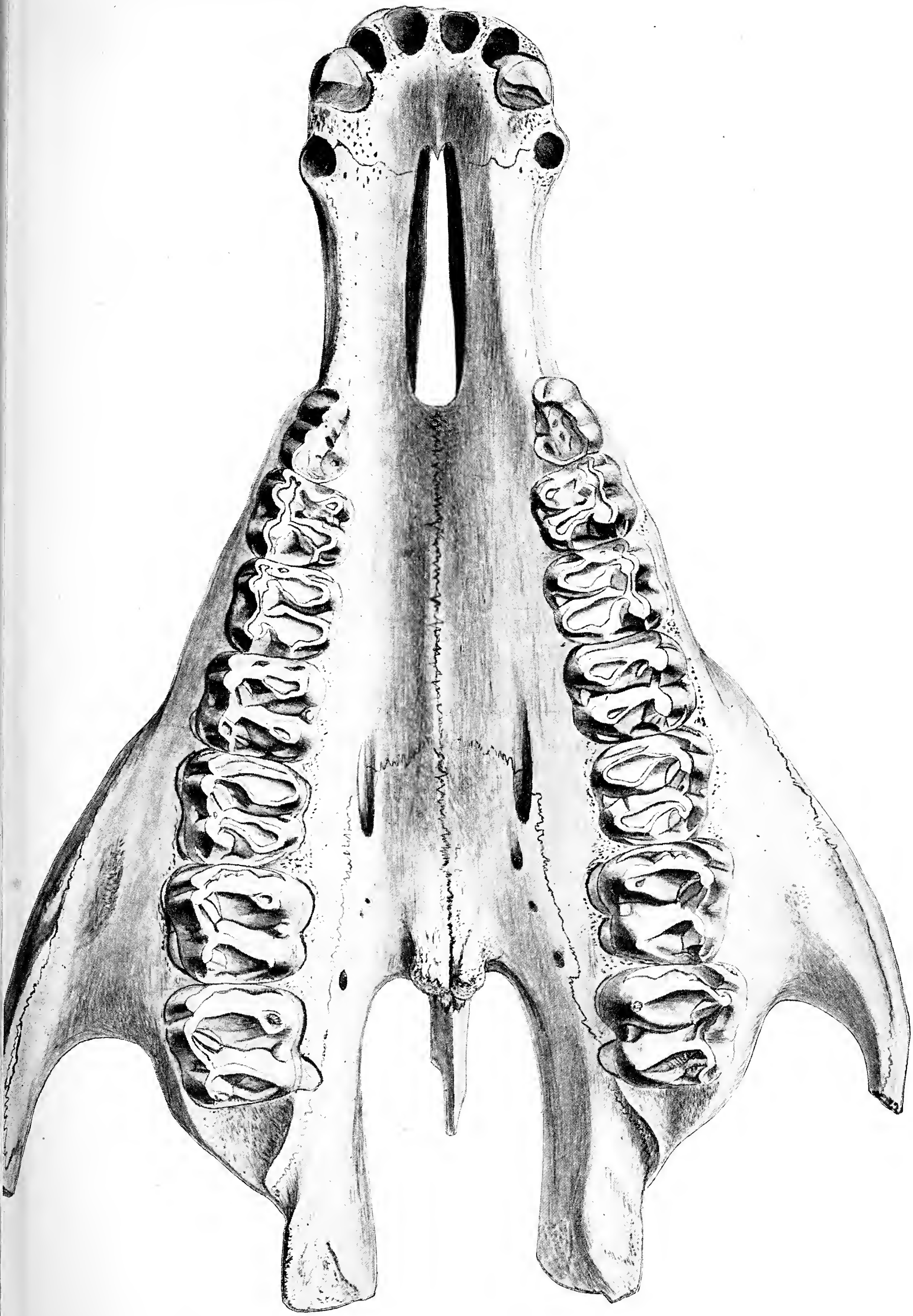
	P. Kennedy	Fla. tapir
Pm^1 anteroposterior	21 mm.	17 mm.
transverse	20 mm.	14.3 mm.
Pm^2 anteroposterior	20.5 mm.	18.5 mm.
transverse	26 mm.	23 mm.
Pm^3 anteroposterior	22.5 mm.	19 mm.
transverse	26 mm.	24 mm.



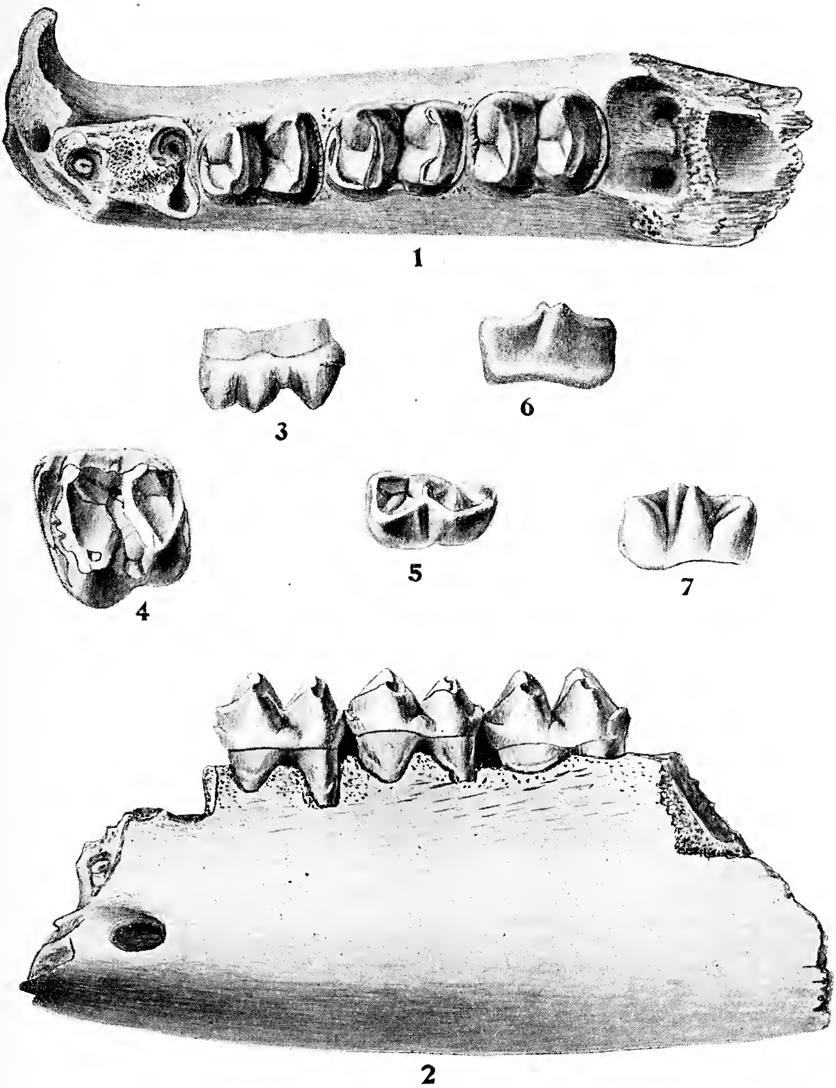
Tapirus veroensis sp. n. Top view of skull. Slightly less than half actual size. Actual length of skull on medium line, 400 mm.



Tapirus veroensis sp. n. Under side of skull. Slightly less than half natural size.



Tapirus veroensis sp. n. Palate. Three-fourths natural size.



Tapirus veroensis sp. n. Figs. 1-2. Top and side views of part of the lower jaw. Figs. 3-4. Side and top views of second upper molar. Figs. 5-7. Side and top views of second lower premolar. All drawings three-fourths natural size.

Pm^4 anteroposterior	26 mm.	20 mm.
transverse	28 mm.	26 mm.
M^1 anteroposterior	25 mm.	21.9 mm.
transverse	28 mm.	26 mm.
M^2 anteroposterior	26 mm.	24 mm.
transverse	31 mm.	28 mm.
M^3 anteroposterior	28 mm.	25 mm.
transverse	32 mm.	29.3 mm.

It is thus seen that as indicated by the teeth the tapir found in Florida is smaller in size than that which has served as the type of *T. haysii*. In addition the illustration of the type tooth of *T. haysii* apparently indicates a tubercle at the outer side of the tooth. blocking in a measure the valley between the transverse ridges. The separation of the Florida tapir from *T. haysii* is based on the difference in size together with the observed difference in structure of the lower teeth, including the absence so far as known of the tubercle at the outer side of the cheek teeth of the Florida tapir which apparently characterizes the larger species.

The relative measurements of the dental series in this specimen from Port Kennedy as compared to *Tapirus veroensis* is shown in the following table of measurements of the two species, the measurements of the Port Kennedy specimen being those given by Dr. Hay (L. C. p. 593). Column 1 is the whole length of the molar-premolar series; column 2, the length of the molar series; column 3, the premolar series; column 4, the measurement of the space between the canine and the first premolar.

	1. M-Pm	2. M	3. Pm	4. C-Pm
Tapirus veroensis	145 mm.	73 mm.	76 mm.	43 mm.
Tapirus haysii	170 mm.	81 mm.	89 mm.	50 mm.

Tapirus haysii californicus, represented by a second lower molar, as described and illustrated by Merriam, is a slightly smaller tapir than *T. haysii,* although probably somewhat larger than the Florida tapir. This tapir, like *T. haysii,* has a tubercle at the outer side of the lower molar tooth between the base of the anterior and posterior ridges. The upper molar described by Merriam from Cape Blanco, Oregon, and placed provisionally by him as near to *T. haysii californicus,* presents structural differences in the teeth by

which it may be separated from *T. veroensis.* The parastyle of the molars of the Oregon tapir, although well developed, is not placed so far to the external side of the tooth as in the Florida tapir. The ridge which braces the paracone of the Oregon tapir is heavy and is confluent with the crest or ridge which forms the posterior margin of the paracone pillar. In the Florida tapir, on the other hand, the buttress which supports the paracone is limited at the posterior side by a rather deeply incised line.

The Florida tapir, apparently, is distinct from both *Tapirus haysii* and the California and Oregon tapir known as *T. haysii californicus.* On the other hand it seems probable that this tapir is identical with some of the fossil tapirs from the Pleistocene of the United States that heretofore, owing to imperfect material, have been provisionally referred to *T. terrestris.* Tapir teeth and fragments of jaws referred to *T. terrestris* have been obtained from several of the states of the Mississippi valley and the South Atlantic coast, although, until more perfect material is obtained or until that which has been obtained can be assembled and closely studied or fully illustrated, it may be difficult to definitely determine the specific reference of these specimens. However, the two molar teeth obtained from Ashley River, South Carolina, and referred by Leidy to *T. terrestris,* present, so far as one may judge from the illustrations, a very close resemblance to the Florida tapir. Unfortunately the parastyle which should afford assistance in identifying the species is broken away from both of these teeth. However, the ridge which passes from the protocone partly crossing the valley between the transverse crests is similar; also the ridge which supports the inner side of the protocone is limited at the posterior side by a constricted line, in which respect the molars resemble those of the Florida tapir. It is to be noted also that the one lower molar illustrated by Leidy from the Ashley River deposits does not show a tubercle blocking the valley between the transverse ridges in which respect it agrees with the lower molars of the Florida tapir. The essential agreement in size, and in such tooth characters as are indicated by the drawings, together with their geographic distribution, suggest that the small tapir from South Carolina is probably identical with this Florida tapir.

RELATIONSHIP TO EXISTING SPECIES.

While the small tapir of the Ashley River deposits may thus provisionally be united with that from Florida, it is certain that the Florida tapir cannot be united with the recent *Tapirus terrestris* of South America. The skull differences have already been indicated. The face of *Tapirus terrestris* is relatively elongated; the crest is strongly developed, especially in old and mature individuals. The spiral groove of *T. terrestris* is more deeply intrenched into the frontals than is that of *T. veroensis*. The lachrymal pit of *T. veroensis* is lacking in *T. terrestris*.

Owing perhaps to the conservative pattern of tapir teeth, the differences in tooth structure between the Recent and Pleistocene species are less pronounced than are some of the other characters of the skeleton. However, where there are such notable skull differences, some characters of systematic value may be expected in the teeth. Such is the case. Notwithstanding the elongation of the face, the molars and premolars of *T. terrestris* are compressed, giving relatively increased transverse measurements; the diastema, on the other hand, is relatively increased. Other differences may be noted. The cingulum at the front outer side of the cheek teeth of *T. veroensis* is stronger than is that of *T. terrestris*. The first upper premolar of *T. terrestris* is much widened at the posterior margin. On the other hand, the anterior division of Pm^2 is not so wide as is the corresponding division of the same tooth of *T. veroensis*. The third molar of the Florida tapir is larger than that of the recent South American species. On both molars and premolars, the ridge or crest which runs to the posterior side of the paracone meeting the anterior walls of the metacone is much stronger on the teeth of the *T. veroensis* than on those of *T. terrestris*. The tubercle which is found in the Pleistocene tapir at the inner side of the upper cheek teeth between the transverse crest, is lacking, or nearly so, in the Recent *T. terrestris*.

These differences, both in the skull and the teeth, separate this fossil tapir from the existing South American species.

ASSOCIATED FOSSILS.

The fossils of the marine shell marl include as known at present 61 species of mollusks, of which one species is apparently an extinct

form, while several others either differ more or less from the recent representatives of the species, or are at present not fully identified. The stratum in which the tapir skull is found contains fresh-water and land mollusks. Of these about 28 species have been recognized, all of which apparently are identical with existing species. Of plants in this stratum, one species, an oak, has been found, and is regarded as identical with the modern *Quercus laurifolia Michx.*, or water oak. From the overlying stratum, No. 3 of the section, 27 plant species have been obtained. Among these is found one extinct species, and 5 others that at the present time do not extend their range into Florida.

The vertebrate fossils associated with the tapir in this stratum are numerous in species and include representatives of diverse groups, including fishes, amphibians, reptiles, birds and mammals. The lists of species of this deposit have been given in papers previously published. According to the studies of Dr. O. P. Hay, the turtles include a considerable number of extinct species. Of birds, two species are recorded from this horizon, both of which apparently represent extinct species. Of the mammals obtained from this horizon about seventy-five per cent are extinct.

A fauna containing so large a percentage of extinct vertebrate species found lying above a marine invertebrate fauna containing so high a percentage of recent species is a matter of considerable geologic interest. The more so since the associated land and fresh-water mollusks are, so far as known, identical with modern forms. From this record, it appears that a vertebrate fauna largely extinct may be expected in the Pleistocene in association with or later than some invertebrate faunas containing largely recent species. In this association of extinct vertebrate species with existing invertebrates, however, it is well to note that the Vero locality does not stand alone. A similar association of largely extinct vertebrates with existing land invertebrates is found in the cavern deposits at Ocala, Florida. The vertebrates from this latter locality were listed in 8th Annual Report of the Florida Geological Survey, p. 103, 1916, although to the list there given several species may now be added. The invertebrates, which have been identified through the kindness of Dr. Paul Bartsch, include 6 species, all of which are in existence

at the present time.* According to Shimek, the land and fresh-water molluskan fauna has remained essentially unchanged from the Aftonian inter-glacial stage to the present time.† The vertebrates, as we know, have changed very decidedly since that time.

To the fossils already mentioned may be added the reported presence of human remains in this stratum. The muck bed immediately above contains human remains and artifacts in relative abundance. From his own observations the writer believes that the human remains and artifacts are present likewise at the stratigraphic level from which this skull was taken. This subject is discussed in papers previously published.‡

GEOLOGIC HORIZON.

The determination of the horizon represented by this assemblage of fossils is very much to be desired. In the publications relating to the locality the correlation has varied under the treatment of different writers from early Pleistocene to Recent. The vertebrate fossils, it will, perhaps, be agreed include species which heretofore have been regarded as characteristic of the Mid—or Early Pleistocene. It has been suggested, however, that in the southern part of the United States, Pleistocene veterbrate species persisted longer than in the northern states, and that the early Pleistocene species may have continued into the late Pleistocene. However, enticing this suggestion may appear on theoretical grounds, it is wise to await other proof before applying unreservedly so broad a generalization, especially as there seems to have been no barrier to interfere with the spread of this fauna to the north-east and north-west, if present in Florida during the late Pleistocene. It has been held also that the horizon holding these fossils is necessarily of late Pleistocene age because it overlies a terrace which is the latest of the Pleistocene terraces of this part of the Atlantic Coast. This terrace, it is said, is of the same age as Talbot of Maryland and New Jersey which is placed as late Pleistocene. It is doubtful, however, if the study of the terraces of Florida has progressed far enough

* The species identified by Dr. Bartsch from a collection made by the writer at Ocala include the following: Succinea campestris, Zonitoides arboreus, Z. minusculus. Helicodiscus parallelus, Polygyra jejuna, and Vitrea indentata.

†Bull. Geol. Soc. Amer. Vol. 21, pp. 110-140, 1910.

‡For a list of papers relating to this locality, see Fla. Geol. Survey, 9th Ann. Rpt., pp. 69-70 and 141, 1917.

to permit this definite correlation, except as supported by fossils. When the terrace in question is followed to the north, it is observed to approach the present shoreline and to disappear somewhat north of St. Augustine by merging with the recent beach terrace. It is possible that the terrace may be again located farther to the north and its relation to the other terraces established. However, until this is done the correlation of the terraces on field observation in the writer's opinion, can not be considered complete.

The fact that recent species of land and fresh water mollusks are associated with the vertebrates can not be regarded, for reasons already given, as affording any conclusive evidence as to the age of the beds. The high percentage of existing species in the underlying shell bed is suggestive as to the age of that deposit. However, no one of the students of the marine mollusks has held, so far as the writer has observed, that the study of that group has progressed far enough to permit the discrimination of horizons within the Pleistocene of the Coastal Plains. There remains the evidence derived from the fossil plants. As already noted, from this horizon there has been obtained but a single species, an oak regarded as identical with a recent species. From the next overlying horizon, however, a much more representative flora has been secured. This flora is regarded by Berry as representing the late Pleistocene and as the equivalent of the Talbot of Maryland and New Jersey. Unfortunately the flora, except the one species referred to, is from above rather than in the horizon under discussion. The opinion has been expressed by Berry, and also by the present writer, that there seems to be no considerable break between the two horizons. However, the suggestion of a possible break interferes with applying strictly the evidence derived from the fossil plants, except as to the one species, to the problem of the age of this stratum. The summary of the evidence thus far available seems to indicate that while the horizon from which this skull has been taken can be shown to be Pleistocene and to be interpolated between other Pleistocene horizons, its exact place within the Pleistocene can not at the present time be regarded as fully determined.

FLORIDA STATE GEOLOGICAL SURVEY.

ELEVENTH ANNUAL REPORT

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EXPENSES GEOLOGICAL SURVEY.

LIST OF WARRANTS ISSUED DURING THE YEAR ENDING JUNE 30, 1918.

JULY, 1917.

Herman Gunter, assistant, expenses for July, 1917	$ 57.12
Herman Gunter, assistant, salary for July, 1917	125.00
Laura Smith, services	44.00
Ed Lomas, janitor services	10.00
E. W. Berry, services	100.00
Maurice Joyce Eng. Co., engravings	5.14
R. S. Chapin, copying	4.95
Lucius Storrs, maps	3.90
Southern Express Company	3.39

AUGUST, 1917.

E. H. Sellards, expenses for August, 1917	53.79
Herman Gunter, assistant, salary for August, 1917	125.00
Laura Smith, services	48.00
Ed Lomas, janitor services	10.00
Geo. D. Barnard & Co., supplies	2.56
G. I. Davis, postage	25.00
Underwood Typewriter Company	48.03

SEPTEMBER, 1917.

E. H. Sellards, State Geologist, salary for quarter ending Sept. 30, 1917	625.00
E. H. Sellards, expenses for September, 1917	25.70
Herman Gunter, salary for September, 1917	125.00
Herman Gunter, expenses for September, 1917	5.20
Ethel Manning, services	36.00
Ed Lomas, janitor services	10.00
Seaboard Air Line Railway Company, freight	3.74
Underwood Typewriter Company, supplies	3.50
H. & W. B. Drew Company, supplies	3.10
Southern Express Company	1.32

OCTOBER, 1917.

E. H. Sellards, expenses for October, 1917	86.32
Herman Gunter, salary for October, 1917	125.00
Ethel Manning, services	45.50
Ed Lomas, janitor	10.00
Geo. D. Barnard & Co., supplies	1.08
Maurice Joyce Engraving Company	25.32
Southern Express Company	2.48
E. O. Painter Printing Co., Printing	287.75

NOVEMBER, 1917.

E. H. Sellards, expenses for November, 1917	61.91
Herman Gunter, salary for November, 1917	125.00
Ed Lomas, janitor services	10.00
E. O. Painter Printing Company, printing	561.61
Geo. I. Davis, postmaster	84.80
Wrigley Engraving Company	23.04
Freight, Georgia, Florida and Alabama Railway	6.06
Southern Express Company	6.01
Maurice Joyce Engraving Company	38.93

DECEMBER, 1917.

E. H. Sellards, State Geologist, salary for quarter ending Dec. 31, 1917	625.00
E. H. Sellards, expense for December, 1917	21.99
Herman Gunter, salary for December, 1917	125.00
Ed Lomas, janitor	10.00
Seaboard Air Line Railway Company, freight	14.96
Geo. I. Davis, postmaster	51.00
The American Journal Science for subscription	6.00
Southern Express Company	3.95

JANUARY, 1918.

Herman Gunter, salary for January, 1918	125.00
Ed Lomas, janitor	10.00
H. & W. B. Drew Company	19.10
T. J. Appleyard, Columbian Envelopes, etc.	10.50

FEBRUARY, 1918.

E. H. Sellards, expenses for January, 1918	83.63
Herman Gunter, salary for January, 1918	125.00
Herman Gunter, expenses for January, 1918	9.70
Ed Lomas, janitor	10.00
Economic Geology Publishing Company	3.50
Southern Express Company	1.87

MARCH, 1918.

E. H. Sellards, State Geologist, salary for quarter ending March 31, 1918	625.00
Herman Gunter, salary for March, 1918	125.00
E. H. Sellards, expenses for March, 1918	113.73
Herman Gunter, expenses for March, 1918	43.92
Ed Lomas, janitor	10.00
H. & W. B. Drew Company, supplies	16.10
Montgomery Map & Blue Print Company	1.25
Georgia, Florida and Alabama Railway Company, freight	2.44
Southern Express Company	3.89

APRIL, 1918.

E. H. Sellards, expenses, April, 1918	119.31
Herman Gunter, salary, April, 1918	150.00
Herman Gunter, expenses, April, 1918	34.41
Ed Lomas, salary, April	10.00
American Peat Society, subscription	3.00
McGraw-Hill Book Company, publications	10.00
Southern Express Company	2.71
C. Van Nostrand Company, publications	2.70
John Wiley and Sons, publications	4.00

MAY, 1918.

Herman Gunter, salary for May, 1918	150.00
Herman Gunter, expenses for May, 1918	52.69
Lila B. Robertson, services	15.00
Alex Quarterman, services	15.00
Ed Lomas, salary	10.00
University of Chicago Press, subscription	3.60
Groover-Stewart Drug Company, supplies	4.35
W. & L. E. Gurley, supplies	39.40
T. J. Appleyard, printing	17.50
Southern Express Company	10.03
D. R. Furniture Company, supplies	41.50
W. L. Marshall	2.00

JUNE, 1918.

E. H. Sellards, State Geologist, salary for quarter ending June 30, 1918	625.00
E. H. Sellards, expenses for May and June	20.50
Herman Gunter, salary for June	150.00
Herman Gunter, expenses for June	33.11
Lila B. Robertson, services	38.08
Alex Quarterman, services	15.00

Ed Lomas, salary	10.00
Charles Williams, floor paint	6.00
H. & W. B. Drew Company, office supplies	18.93
D. R. Cox Furniture Company, office supplies	53.00
Southern Express Company	4.99
Geo. I. Davis, postmaster, postage	27.00
Total expenditure for the year ending June 30, 1918	$6,613.84
Overcharge from the preceding year	123.70
	$6,737.54
Appropriation for the year	$7,500.00
Balance available	$ 762.46

GEOLOGY BETWEEN THE CHOCTAWHATCHEE AND APALACHICOLA RIVERS IN FLORIDA.

BY E. H. SELLARDS AND H. GUNTER.

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GEOLOGY BETWEEN THE CHOCTAWHATCHEE AND APALACHICOLA RIVERS IN FLORIDA.

E. H. SELLARDS AND H. GUNTER.*

LOCATION, AREA AND MINERAL INDUSTRIES.

H. GUNTER.

The area to which this report relates lies in western Florida between the Apalachicola and Choctawhatchee rivers. It extends from the State line at the north to the Gulf of Mexico, and includes Jackson, Calhoun, Holmes, Washington and Bay counties. The total area is 3,890 square miles, or 2,489,600 acres.

CLIMATE.

Records on temperature and rainfall are available at the Marianna Station from the United States Weather Bureau. This station probably may be accepted as fairly representative of the area covered by this report. The average for rainfall and temperature at Marianna is based on records from 1912 to 1916.†

The annual mean temperature at Marianna, in Jackson County, is 67.4 degrees Fahrenheit. The mean for the four seasons of the year is as follows: Winter, 56.6; Spring, 77.3; Summer, 76.3; Fall, 57.7; the maximum summer heat recorded at this station during this five year period is 106 degrees Fahrenheit. The minimum winter temperature recorded is 22 degrees Fahrenheit.

The annual mean rainfall at Marianna is 56.3 inches. This is distributed throughout the year as follows: January, 3.4 inches; February, 6.3 inches; March, 5.2 inches; April, 3.5 inches; May, 3.1 inches; June, 4.4 inches; July, 8.9 inches; August, 5.5 inches; September, 5.8 inches; October, 3.3 inches; November, 2.4 inches; December, 4.0 inches.

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*The field work on this report has been done jointly by the authors. The manuscript has been prepared as indicated.

†Climatological Data, Florida Section, Annual Summary for years 1912-1916, by A. J. Mitchell, U. S. Dept. Agri., Weather Bureau Office, Jacksonville, Florida.

VEGETATION.

The rolling uplands of the northern part of this area, although largely cleared at the present time, supported originally a mixed timber growth, including short-leaf pine and many hardwood deciduous trees, such as red oak, live oak, hickory, dog-wood and magnolia. The chief timber growth of the lands in the southern part of the area is the long-leaf pine. In the flatwoods the undergrowth associated with this pine is chiefly saw-palmetto. In the well drained areas the undergrowth consists largely of the black-jack oak.

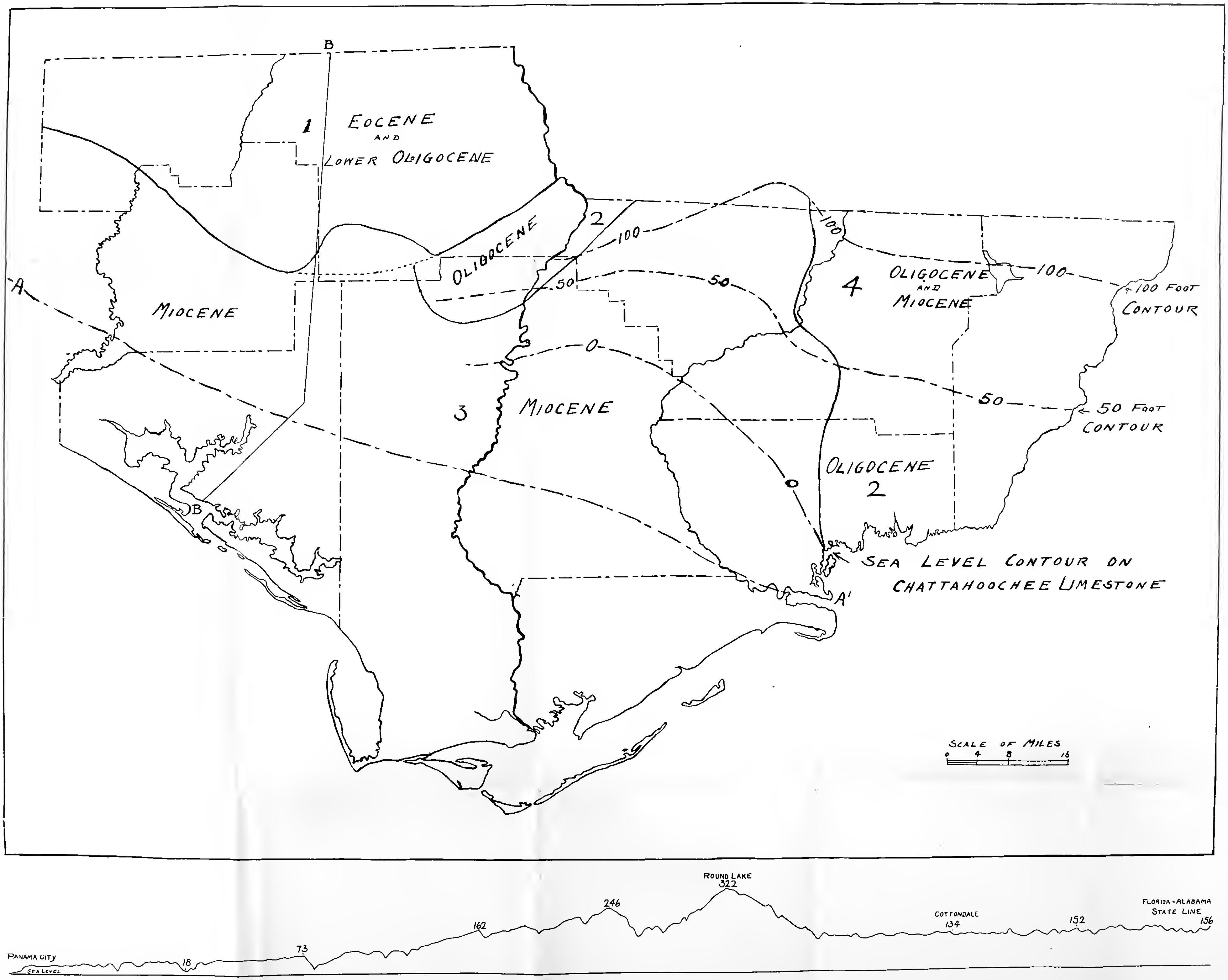
When studied in detail the vegetation of this area may be divided into several more or less well-marked vegetation types, and in his report on the vegetation of northern Florida, published in the Sixth Annual Report of this Survey, Dr. R. M. Harper has indicated eight vegetation types within this area. The plants characterizing each type are there listed.

ELEVATIONS.

The only precise levels available in this area are bench marks established by the U. S. Army Engineers. These are placed on the west bank of the Apalachicola river in Jackson county. In addition to these precise levels the profiles and levels of railroads have been available in determining elevations. The profile of the Atlanta and St. Andrews Bay railway, shown on a map accompanying this report, was made possible through levels obtained from Mr. Arthur Pew, Civil Engineer, Atlanta, Georgia and Mr. B. W. Steele, President, Dothan, Alabama. All levels obtained have afforded material assistance in the study of the topography and geology, and the writers wish to express their appreciation of the assistance thus received which has very much facilitated the preparation of this report.

The following is a description of the bench marks that have been established upon precise level within this area.

About two miles west of River Junction, 65 meters west of west concrete pier of Louisville and Nashville railroad bridge over the Apalachicola river, 1 meter north of trestle, bench mark is the top of a copper bolt set in a concrete post. Elevation, 63.786 feet.



SKETCH MAP OF AREA BETWEEN THE CHOCTAWHATCHEE AND AUCILLA RIVERS.

1. Belt of country in which Eocene and Lower Oligocene formations are occasionally exposed at the surface.
2. Belt in which Oligocene, chiefly Upper Oligocene, lies at or near the surface.
3. Large Miocene belt, including both Upper and Lower Miocene, Alum Bluff and Choctawhatchee formations. The Lower Miocene in this belt extends into Georgia. The approximate sea level contour on the Lower Miocene is indicated by the line AA'.
4. Belt of remnants of Lower Miocene overlying Upper Oligocene.

The 0, 50 and 100 foot contours, indicated by broken lines, are placed approximately on the top surface of the Chattahoochee formation.

Profile: The location of the profile across this area is indicated approximately by the line BB. Scale of profile: Horizontal, 1 inch equals 3½ miles; vertical, 1 inch equals 250 feet.

Formations later than the Miocene are not shown on this sketch.

About two miles west of River Junction in the triangle formed by three blazed trees; one of which is a 20-inch white oak, distant 20 feet; another is a 24-inch post oak, distant 100 feet; and the other is a 10-inch walnut, distant 127 feet. The bench mark is a copper bolt in a concrete post, 100 meters southwest of the west concrete pier at the west end of the Louisville and Nashville railroad bridge over the Apalachicola river and about 3 meters from the bank of the river. Elevation, 64.062 feet.

The elevations on the Atlanta and St. Andrews Bay railroad may be determined approximately from the profile, (See map) which is based on levels made by Mr. Arthur Pew. Mr. Pew made levels also on the Marianna and Blountstown railroad from Marianna to Blountstown, and on the Birmingham, Columbus and St. Andrews railroad from Chipley to Southport. The elevation at the end of the track on the river bank at the landing at Blountstown, according to Mr. Pew is 63.86 feet lower than the base of the rail at the depot at Marianna. The level at Marianna according to the corrected levels is 115 feet. Hence the actual level at Blountstown landing is 51.1 feet above sea. The elevation at the base of the rail at the depot at Chipley according to the corrected levels is 103.31 feet. The maximum elevation shown by the profile across this area is 322 feet near Round Lake.

The elevations on the Louisville and Nashville railroad have been kindly supplied by Mr. W. H. Courtenay, Chief Engineer. The profile and levels on this road, as checked on the bench mark at the Apalachicola river appear to be about 5.7 feet above the actual levels as established by the U. S. Army Engineers.* This correction has been made in the elevations as here listed. The levels given are at the base of the rail opposite the mile post.

* According to the levels supplied by Mr. Courtenay the track level on the bridge at the Apalachicola river is 88.5 feet. The actual level at the base of the rail on the drawbridge as determined from the bench mark near by is 82.73 feet above sea. The difference, 5.7 feet, is the correction applied in these levels.

LEVELS ON THE LOUISVILLE & NASHVILLE RAILROAD FROM NEAR ARGYLE TO THE APALACHICOLA RIVER.

Mile Post number "L"	Elevation	Mile Post number "L"	Elevation
735	252.3	773	129.0
736	256.9	774	127.3
737	238.0	775	129.7
738	213.8	776	136.6
739	162.3	777	143.6
740	134.6	778	140.6
741	109.4	779	131.6
742	73.6	780	144.6
743	62.6	781	153.1
744	78.3	782	162.1
745	57.0	783	148.5
746	62.3	784	152.1
747	66.7	785	161.3
748	66.8	786	165.8
749	67.8	787	148.8
750	60.2	788	102.3
751	64.4	789	82.0
Draw of bridge over Choctawhatchee river	61.7	790	96.8
752	57.8	791	96.8
753	72.7	792	118.8
754	87.6	793	114.3
755	101.8	794	138.3
756	107.9	795	126.3
757	112.4	796	127.6
758	124.0	797	112.4
759	133.5	798	128.3
760	120.9	799	143.2
761	97.3	800	156.2
762	82.7	801	158.8
763	76.1	802	122.8
764	64.4	803	128.5
765	67.4	804	140.2
766	80.8	805	168.9
767	92.3	806	148.5
768	80.7	807	113.2
769	103.2	808	101.7
770	98.8	809	100.4
771	110.5	810	96.4
772	127.0	811	74.9
		Drawbridge on Apalachicola river	82.8

MINERAL INDUSTRIES.

BRICK-CLAYS.

Four brick-making plants, the Florida Industrial School for Boys, at Marianna; Hall and McCormac, Chipley; G. C. & G. H. Guilford, Blountstown, and Converse Brick Company, Wetappo are located in this area. No clay product other than common building brick is at present being manufactured.

Two samples of clay from this area have been tested in the U. S. Bureau of Mines Clay Testing Laboratory at Pittsburg, Pa. Sample No. 1 is from the Florida Industrial School for Boys, Marianna, sample No. 2 from the brick plant of Hall and McCormac, Chipley. The report of these samples taken from Press Bulletin No. 7 of the Florida Geological Survey, is as follows:

Sample No. 1, Jackson County. The clay works with some difficulty in the stiff mud condition; water of plasticity in per cent of dry weight, 40.80 per cent; warped and cracked during the drying treatment; linear drying shrinkage in terms of wet length, 9.95 per cent; linear burning shrinkage in terms of dry length, at 850 degrees C., 0.77 per cent; at 1010 C., 4.59 per cent; at 1130 C., 6.60 per cent; at 1250 C., 7.55 per cent; color after burning, light red at lower temperature, changing to dark red at higher; per cent porosity, at 850 degrees C., 36.75 per cent; at 950 C., 40.55 per cent; at 980 C., 34.30 per cent; at 1010 C., 30.30 per cent; at 1040 C., 24.20 per cent; at 1070 C., 24.00 per cent; at 1100 C., 26.10 per cent; at 1130 C., 25.15 per cent; at 1160 C., 23.65 per cent; at 1190 C., 23.60 per cent; at 1220 C., 23.85 per cent; at 1250 C., 20.70 per cent. A somewhat plastic and sticky clay of high drying and burning shrinkage. The clay retains a porous structure at 1250 degrees C. (2282 degrees F.), and cannot be used in the manufacture of vitrified ware burned in commercial kilns. The clay may be used in the manufacture of common and building brick.

Sample No. 2, Washington County. The clay possesses good working plasticity and molding behavior; water of plasticity, 36 per cent; a few cracks developed by drying; linear drying shrinkage, 9.42 per cent; linear burning shrinkage, at 850 degrees C., 0.55 per cent; at 1010 C., 1.57 per cent; at 1130 C., 7.75 per cent; at 1250 C., 8.10 per cent. A good light buff color is developed by burning; per cent porosity, at 850 degrees C., 36.80 per cent; at 950 C., 35.30 per cent; at 980 C., 34.75 per cent; at 1010 C., 34.50 per cent; at 1040 C., 30.75 per cent; at 1070 C., 25.70 per cent; at 1100 C., 22.45 per cent; at 1130 C., 19.70 per cent; at 11.60 C., 17.95 per cent; at 1190 C., 15.70 per cent; at 1220 C., 14.60 per cent; at 1250 C., 12.55 per cent. A buff burning clay of good plasticity and a relatively high drying shrinkage. May be used in the manufacture of buff colored face brick, although care must be exercised in drying. The clay must be burned above 1250 degrees C. in order to attain low porosity.

LIMESTONE.

The limestones of this area have been used quite extensively in the construction of buildings, for foundation work and for chimneys. The limestones are found principally in the northern part of the area particularly in Jackson County in the vicinity of Marianna and the northern part of Washington County a few miles south of Chipley. The limestones of the Ocala and Marianna formations are very soft and friable and are cut with a cross-cut saw into desired size blocks for construction purposes. Upon exposure these blocks become more or less hard and make a very desirable building block. This limestone runs uniformly high in calcium carbonate and contains but little foreign impurities. It should make a good material for agricultural purposes as well as for the manufacture of a high grade lime.

PHOSPHATE.

The Alum Bluff formation, which is frequently seen in the stream banks, is often, here as elsewhere, more or less phosphatic. Some attempt to get phosphate from this formation on Econfina Creek was made some years ago. A company was organized under the name of the Econfina Phosphate Company and a small plant constructed. From the banks of the Chipola River below Clarksville samples of the sand rock of the Alum Bluff Formation were found to be slightly phosphatic. No localities are known in this area, however, which appear to contain workable phosphate deposits.

ROAD MATERIALS.

The principal road building materials of this area are sandy clays, limestones and gravel. The clays are very generally distributed over the northern part of the area and are extensively used in surfacing roads. The limestones have been but little used as road metal. The gravel found in the northern part of the area is now being quarried and used in the construction of the roads of Bay county.

SANDS AND GRAVELS.

Some of the best and most extensive deposits of sands and gravels occurring in Florida are found within this area. These are quite generally distributed from the southern part of Jackson county

near Cottondale south to the Gulf near Panama City. About four miles south of Cottondale near Steele City the gravel is being quarried for road purposes. The material varies in size from small pea-like grains to rounded elongated pebbles five to six or more inches in length. Large deposits of gravel are known to occur in the vicinity of Round lake, although the only deposits quarried at the present are those near Steele City.

Farther south the gravel becomes smaller until near Panama City on the Gulf Coast it grades into an excellent grade of coarse building sand.

WATER SUPPLY.

The water supply in this area is obtained from wells and springs. The well from which the city water supply at Marianna is taken is 386 feet in depth. The city well at Panama City is 630 feet deep. The public water supply at Vernon is obtained from a well 190 feet in depth. The well for public water supply at Bonifay is 518 feet deep. At Blountstown a flowing artesian well was obtained at a depth of 234 feet. From records published in the Fourth Annual Report of this Survey it is seen that artesian wells have been obtained throughout this area at depths varying from 115 to 630 feet. Shallow dug or driven wells are used in many localities and obtain water from the sands or clays or from the limestones. On the Gulf coast and for some distance inland on the streams flowing artesian wells are obtained at a moderate depth.

SPRINGS.

The principal springs are the large limestone springs in the northern part of the area. The largest and best known of these is Blue spring about six miles northeast of Marianna. This spring is the source of Blue Springs creek which flows into the Chipola river. Morrison and Ponce de Leon springs in Holmes county are limestone springs which flow into Sandy creek, a tributary of the Choctawhatchee river. Aside from the limestone springs which are numerous there are many soft water springs in the clayey upland section. These smaller springs receive their supply of water from the sands and clays lying above the limestones.

TOPOGRAPHY AND GEOLOGY.

E. H. SELLARDS.

In its topographic forms this area presents some apparent anomalies. In passing inland from the coast, the land surface rises gradually to a maximum height, 40 miles inland, of about 322 feet. From this elevation the land surface drops abruptly to 135 feet above sea within a distance of 4 miles. From here the elevation again rises very gradually to 156 feet near the State line. The escarpment marked by this slope which amounts to between 150 and 200 feet, extends across the area from the Choctawhatchee to the Chipola-Apalachicola river valleys. At the east side of the Apalachicola, a similar escarpment extends beyond the boundary of Florida. A less well marked escarpment is found on the west side of the Choctawhatchee river. To the north of this escarpment in this area the country is underlaid by limestones, and has a varied topography including sinks and solution valleys. Under the plateau, south of the escarpment, the limestones lie at a much greater depth, and their influence on topography is not so obvious. The development of the topography in this area may conveniently be described after an account has been given of the geology of the region.

RIVERS.

The Apalachicola river at the east margin of this area is the largest river in Florida. Originating in the highlands of Georgia, this river carries a heavy load of sediment and is one of the few muddy-water streams of the State. The Chipola river, its chief tributary in Florida, on the contrary, is a clear-water stream. The Choctawhatchee river borders the western margin of this area.

THE DEAD LAKES OF THE CHIPOLA RIVER.

The valley of the Apalachicola river is being rapidly aggraded by reason of the load of sediment carried by that stream; the valley of the Chipola, on the other hand, is being built up, much more slowly. The result has been a blocking of the Chipola at its entrance into the Apalachicola by sediment carried by the main stream, thus forming the body of water known as the "Dead Lakes" in Calhoun County. Pine Log creek, a tributary entering

the Choctawhatchee from the east is blocked in the same way, forming a lake several square miles in area.

The following account of the origin of the lakes of the Chipola river has been given in volume 27 of the bulletins of the Geological Society of America.*

The Chipola river in Florida affords a good illustration of a tributary stream ponded by the deposition of sediment in the valley of the main stream. This river, which originates entirely within the coastal plain, flows for a considerable part of its course across limestones and is fed very largely by clear water limestone springs. It is therefore a clear-water stream, carrying only a limited amount of sediment. The Apalachicola river, of which the Chipola is a tributary, heads, on the contrary, in the mountains of northern Georgia and receives a heavy load of sediment, which is deposited, as the river becomes overloaded, near the Gulf. The Chipola enters the Apalachicola about 25 miles, by land, from the Gulf of Mexico. In this lower part of its course the Apalachicola is rapidly aggrading its valley, while the Chipola, owing to the limited amount of sediment which it carries, is building its valley much more slowly. This condition results in flooding the valley of the Chipola river. The lake thus formed, known as the Dead Lake of the Chipola river, derives an added interest from the fact that it has come into existence so recently that the cypress timber of the former river swamp, now mostly dead, is still standing, although the water in the lake has reached a depth of from 10 to 20 feet, while the lake itself is 10 or 12 miles long and from 1 to 2 miles wide. The channel of the river may still be followed in its winding course through the lake.

GEOLOGY.

The geologic formations found at the surface within this area are chiefly those of the Eocene, Oligocene, and Miocene periods, altho more recent deposits may be present near the Gulf Coast. As in the case of the other formations of Florida the materials of which these formations are made include chiefly sands, clays, limestones and shell marls. The limestones have been divided on the basis of the kinds of fossils which they contain into three formations, known as the Ocala, the Marianna, and Chattahoochee formations. The shell marls likewise are readily divided into at least two formations differing in age and in the kinds of fossil shells which they contain. These are known as the Alum Bluff and the Choctawhatchee formations.

* Dead lakes of the Chipola river, Florida. By E. H. Sellards, Bull. Geol. Soc. Amer., Vol. 27, p. 109, 1916.

The following table includes a summary of the formations of this area as they are at present defined. All of these formations fall within the latest of the large divisions of geologic time, the Cenozoic. The earliest or oldest formation is placed at the bottom of the table, the latest at the top.

Pleistocene. The presence of Pleistocene formations has not been demonstrated, although deposits of this age may come in near the coast.

Pliocene. The presence of fossiliferous marine Pliocene has not been determined within this area.

Pliocene-Miocene. Uppermost formation of a part of this area consisting of coarse sands and streaks and lenses of clay.

Miocene. Choctawhatchee formation: Shell marls and sands.
Alum Bluff formation: Calcareous sands, clays and shell marls.

Oligocene. Chattahoochee formation: Impure clayey limestones.
Marianna formation: Chiefly pure limestones.

Eocene. Ocala formation: Pure white limestones.
Claiborne formation: Glauconitic sands.

DESCRIPTION OF FORMATIONS.

EOCENE.

CLAIBORNE FORMATION.

Deposits of Claiborne age which are extensively developed in Alabama and Georgia are regarded as probably extending a short distance into Florida. If so these are the oldest formations exposed at the surface in the State. The extension of the Claiborne to the Florida State line on the Choctawhatchee River was recorded by Dr. E. A. Smith in 1894.* The exposures on this river were examined by the writers in 1915. On the left bank of the Choctawhatchee River for a short distance below the Florida-Alabama State line there is exposed a green glauconitic sandy limestone. As much as about 8 feet of this rock shows at low water stage, the upper five feet being more sandy than that at a lower level. Fossils in this rock are rare, the only species obtained in Florida being a small Pecten. Lithologically this rock is similar to the much more fossiliferous Claiborne deposits exposed at Geneva, Alabama, on both the Choctawhatchee and Pea rivers, and

* Report on the Geology of the Coastal Plains of Alabama, Geol. Surv. of Alabama, 1894, pp. 673-675.

may be referred provisionally to the Claiborne. These exposures, which may be seen for about one and three-fourth miles below the State line, probably represent the upper part of the Claiborne, since limestones of later age come into the section only a few miles farther down stream. It is probable that this formation is reached by many wells in the northern part of this area.

STRUCTURE.

In his report on the Coastal Plains of Alabama, Dr. Smith has shown that the normal line of outcrop of the Claiborne deposits on the Choctawhatchee River lies near the north line of Geneva County, Alabama, and hence some miles north of the Florida line. The recurrence of these deposits at Geneva is interpreted by Dr. Smith as indicating an interruption in the rate of dip amounting to a fold in the rocks. This interpretation of the structure, announced in 1894, so far as the writer is aware, has not been questioned. With regard to the exposures in Florida, it is observed that the dip to the south carries the formation below water level in the river within a short distance south of the Alabama-Florida State line.

OCALA FORMATION.

The Ocala formation, which consists chiefly of very pure limestones, has been identified by Dr. C. W. Cooke at several exposures on the Chipola River near Marianna. One of these exposures which has been described by Cooke is that at the public road crossing one-half mile east of Marianna.* The Ocala limestone at this place has a thickness of about ten feet or more above water level. Elsewhere in this area the Ocala formation has not been separated from the lithologically similar limestones of the overlying Vicksburg formation.

STRUCTURE.

The Ocala formation dips to the south and passes below water level in the Chipola River probably not far below Marianna. On the Chattahoochee River, according to the observations of Cooke and Shearer the formation remains above water level to a point

* The Age of the Ocala Limestone, by Charles Wythe Cooke, U. S. Geol. Surv., Prof. Paper, 95-I, 1915.

some few miles above the confluence of this river with the Flint River.*

OLIGOCENE.

MARIANNA FORMATION.

The Marianna formation, the type locality of which is at Marianna, Florida, includes chiefly limestone similar in appearance to those of the Ocala formation. These limestones are extensively exposed in the vicinity of Marianna. Other limestone exposures representing either this formation or the Ocala formation are frequent over much of the northern part of the area. At Marianna the limestone of this formation has a thickness as shown by the section made by Cooke of 33 feet. On the Choctawhatchee River limestones are occasionally exposed from a few miles south of the State line to within one or two miles of the crossing of the Louisville & Nashville Railway at Caryville. To the south of Caryville this limestone fails to show in the river banks and presumably has dipped below water level.

STRUCTURE.

On the Chipola River the Marianna formation remains above the water level for some miles below Marianna. In the area intervening between the Chipola and Choctawhatchee Rivers limestones of either Eocene or Oligocene age are found occasionally exposed as far south as the vicinity of Wassau in Washington county. The recorded exposures of these formations indicate a pronounced extension of these limestones into Florida in a general northeast-southwest direction, the maximum southward extension being near or somewhat west of the central part of this area.

CHATTAHOOCHEE FORMATION.

The Chattahoochee formation which includes chiefly limestones more or less impure from clay inclusions is well exposed on the Chipola and Apalachicola Rivers. The sections which best represent this formation on the Apalachicola River have already

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* Deposits of Claiborne and Jackson Age in Georgia, by Charles Wythe Cooke and Harold Kurtz Shearer, U. S. Geol. Surv., Prof. Paper, 120-C, 1918.

been given, p. 31. On the Chipola River the rocks of this formation are exposed at places from some miles south of Marianna to Baileys Ferry in Calhoun County. This formation has not been identified west of the Chipola River, and apparently does not extend to the Choctawhatchee River.

STRUCTURE.

The dip of the Chattahoochee formation as measured on the Apalachicola River, as already stated, appears to be at an average rate of about 7 feet per mile. On the Chipola River the rate of dip has not been determined.

However it is considerably in excess of the gradient of the stream as is indicated by the fact that the formation which comes into the section somewhat below Marianna passes below water level a few miles north of Clarksville.

MIOCENE.

ALUM BLUFF FORMATION.

The Alum Bluff formation which consists largely of sands, clays, and shell marls is exposed on all of the larger streams of this area. The exposures on the Apalachicola River have been described. The Chipola marl at the base of this formation is well exposed on the Chipola River and its tributaries, especially on Ten Mile Creek north of Clarksville. On Econfina Creek are found exceptionally good and complete exposures of the marl phases of the formation. On the Choctawhatchee River are found other good exposures of the formation which remains above water level on this river almost to tide water. The belt of out cropping of this formation extends across this area in a general east-west direction, or from slightly south of east to north of west.

SECTION AT BOYNTON LANDING ON THE CHOCTAWHATCHEE RIVER.

The following section was observed by the writers at Boynton Landing on the Apalachicola River, 35 miles by river from the Gulf, and a few miles above the entrance of Holmes Creek:

4. Sloping and covered with sand and pebble ---------------------- 25 ft.
3. Limestone ledge, fossils mostly as casts -------------------------- 3 ft.
2. Yellow and blue clays, leaf impressions ------------------------- 2 ft.
1. Marl with many fossils mostly preserved as casts, silicified oysters abundant near the top -- 6 ft.

Numbers 1 to 3 of this section represent the Alum Bluff formation. From the leaf impressions Mr. E. W. Berry identified the species *Fagara apalachicolensis* and *Sabalites apalachicolensis,* both of which had previously been obtained from the Alum Bluff formation at Alum Bluff. (Letter of March 21, 1916). The invertebrate fossils obtained at this locality are being utilized by Dr. Gardner in her study of the faunas of the Alum Bluff formation.

At Red Head Still on the east bank of the Choctawhatchee River 25½ miles from the Gulf, is an exposure of oyster shell marl and clay, about five feet being seen above low water. The fossils from this locality include chiefly a very large oyster which Miss Gardner has identified as *Ostrea haitensis,* a species common in the West Indies and in the Alum Bluff formation.* This exposure is a few miles above the post office Ebro, but below the entrance of Holmes Creek.

STRUCTURE.

The position of the belt of outcrops of the Alum Bluff formation indicates that the strike of the formation in this area is from slightly north of west to south of east. The dip to the south or slightly west of south although moderate is in excess of the gradient of the streams. On the Choctawhatchee River, as has been stated, the shell marl phase of the formation remains above water level to within a few miles of tidewater. It is probable that on Choctawhatchee Bay this formation will be found scarcely above tidewater. On the Apalachicola River the formation, as previously noted probably lies above water level as far south as Estiffanulga which is slightly south of east of its last observed exposure on the Choctawhatchee River. On the Chipola River the formation is known to pass below water level a few miles below Clarksville, the Choctawhatchee formation being at water level at Darling Slide and at Abes Spring. Since these two formations are unconformable it is difficult to determine whether the sections of the

* Letter of January 25, 1916.

Chipola River indicate more rapid dip in this formation or rather more erosion from the top surface previous to the deposition of the Choctawhatchee formation. On the Ocklocknee River, as previously recorded the Alum Bluff formation remains above water level to tidewater. In the sketch map, page 80, the line AA represents approximately the position of tidewater level on this formation. Owing to the few available exposures this line can be regarded as only approximate. The formation is probably to be expected near the surface at the coast line except at the mouth of the Apalachicola River where it has been rather deeply buried and the coast line built out by sediments carried by the river.

CHOCTAWHATCHEE FORMATION.

The Choctawhatchee formation, which includes a highly fossiliferous shell layer at its base and a clay member above, is well exposed on some of the streams and rivers which cross this area. On the Apalachicola River all the known exposures are those found on the east bank from Watsons Landing to Johnson's place a distance of about 10 miles. These exposures have been described. On the Chipola River good exposures are found on Four Mile Creek near Clarksville, and at Darling Slide farther down the River. On Econfina Creek at and below Econfina post office are exposures of a shell marl which is probably of this formation. The same shell marl is found at a locality known as the "Deadens" in Washington County, (S18, T1W, R13W), indicating that the shell marl underlies the highlands of that county. On the Choctawhatchee River few if any exposures of this formation are found immediately on the river. Back from the river a short distance however, especially on the west side, are numerous exposures of the shell marl phase of the formation. According to Matson, the shell marl phase of the formation on the west side of the Choctawhatchee River attains a thickness of 30 or more feet.*

STRUCTURE.

An estimate of the rate of dip of the Choctawhatchee formation on the Apalachicola River has already been given. It is there found to dip to the south at a rate apparently not exceeding about

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* Fla. Geol. Surv., 2nd Ann. Report, pp. 117, 1909.

2 1-3 feet per mile. From the exposures on the Chipola River only an approximate estimate of the rate of dip of the formation can be given. On Four Mile Creek near Clarksville the base of this formation lies 13 feet above water level in the river, while 4 or 5 miles below Clarksville at Darling Slide and Abe's Spring, the base of the formation is somewhat below water level, indicating a dip to the south of 3 feet or more per mile.

In order to get further data on the position of this formation, levels were made at one place west of the Choctawhatchee River.* The Choctawhatchee marl on John Anderson's farm about 1 mile south of Red Bay in Walton County lies 102 feet above water level in the river, date of June 5, 1918. The base of the formation lies from 10 to 30 or more feet below the exposure from which the levels were taken, or between 70 and 90 feet above water level in the river. On the following day the water level in the river at the Louisville & Nashville Railway crossing was found from known levels on the railway to be 33.3 feet above sea. From this crossing to the Bay at the mouth of the river, following the course of the stream, is probably between 30 and 35 miles. Hence the fall of the river in this part of its course is close to one foot per mile. From the Louisville & Nashville Railway crossing to Red Bay, following the general course of the river, is about 13 miles. Hence water level in the river at Red Bay is close to 20 feet above sea, and the level of the base of the Choctawhatchee formation at this place accordingly is probably between 90 and 120 feet above sea. These measurements indicate that in passing from east to west, or slightly north of west, the Choctawhatchee formation lies essentially at a uniforn level, the dip being south or slightly west of south.

MIOCENE-PLIOCENE?.

In this area as in the country to the east of the Apalachicola River, depisits of sand, pebble and clay lie above the Choctawhatchee formation. On Four Mile Creek near Clarksville about 65 feet of sandy material, mostly covered by the sloping hill, overlies the Choctawhatchee formation. At Round Lake and in some other

*Levels made by H. Gunter, June 5, 1918.

cuts on the Atlanta and St. Andrew's Bay railway are seen exposures which appear to represent this formation. Likewise on the west banks of the Choctawhatchee River a considerable thickness of similar material is found overlaying the Choctawhatchee formation. These deposits presumably represent the westward extension of the materials found overlying the Choctawhatchee formation between the Apalachicola and Ocklocknee Rivers.

SANDS AND GRAVELS.

At places within this area are found coarse sands, gravel, and pebbles. The pebbles are chiefly fragments of quartzite rocks. These pebbles vary from a few ounces to from one-half to one or two pounds in weight. Most of them are water worn and rounded, although occasionally rocks are found that are distinctly angular. Deposits of these gravel found four miles south of Cottondale (S13, T3N, R12W), are being utilized in road building in Bay County. Other deposits as yet not utilized are found near by.

The gravel beds that are being worked are found near the base of the escarpment which divides the lower lands of the northern part of the area from the higher lands farther south. However, at a locality about one mile west of Round Lake is found a bed of gravel consisting of medium seized pebbles that lies well up on the highlands. The position of this bed suggests that the deposits found at the lower level may be concentration products from the higher lands. Samples of these pebbles were submitted for examination to the U. S. Geological Survey. In commenting upon the pebbles, the acting director of the Survey states:* The pebbles that you submitted seem to be quartzite but whether they originated in the Coastal Plain or in the region of metamorphic rocks seems to be indeterminate.

TOPOGRAPHIC AND PHYSIOGRAPHIC DEVELOPMENT OF LAND FORMS.

The geologic structure in this area has influenced the topographic and physiographic development. The position and direction of the principal streams seem to have been determined by the structure. As has been shown the Eocene and Oligocene lime-

*Letter of July 10, 1918.

stones project into this area having a general northeast-southwest trend. The Apalachicola River skirts the east side of this belt of limestones and approximately parallels its structural axis. On the west side, the Choctawhatchee river likewise approximately parallels the structural axis. For reasons previously given (p. 26) the principal tributaries of the Apalachicola River in Florida enter from the west. For similar reasons the principal tributaries of the Choctawhatchee River in Florida enter from the east. On the west side of the Apalachicola, and on the east side of the Choctawhatchee Rivers is found a belt of low land. Originally, perhaps the surface elevation in the northern and north central part of this area was greater than that either to the east or south. This elevation, however, was reduced by surface wash by tributaries from the two streams. The rate of lowering was increased by subsidence due to solution in the underlying limestones. As a result of combined surface wash and underground solution the part of this area which originally we may well believe was highest in elevation, has at present come to be lower than much of the land farther south. By these agencies was produced the north facing escarpment which is the most pronounced topographic feature of this belt of country, marking the dividing line between the lower lands of the limestone country and the higher lands of the plateau.

The agencies that have been most active in reducing the land level in the limestone areas have been surface wash and underground solution. On the plateau may be observed the effects of solution in the underlying formations. Near the northern margin of the plateau are many small round lakes. The basins of these lakes have obviously been formed by solution in the Miocene shell marls which underlie the uplands. While many of the basins thus formed are small, others have been much enlarged by these agencies. One of the largest of these basins is that known locally as the "Deadens" in Washington County. In the sinks in this basin in the dry season may be seen exposures of the limestone and shell beds to the presence of which the basin owes its origin. The streams which flow to this basin disappear through these sinks, entering the calcareous formations. In most of the lakes, especially the smaller ones, the sides are sloping and sand covered

and the shell marl is not exposed and in many cases probably lies below water level in the lake.

As a result of these eroding agencies the escarpment which divides the low land at the north from the higher land at the south slowly migrates southward. The country near the north margin of the plateau which now contains the many lakes is a transition belt. The presence of the lakes is evidence of the beginnings of the disintegration of the materials overlying the limestones. On the other hand, occasional hills stand out to the north of the main escarpment which are remnants of the former northward extension of the plateau. Among such hills within this area may be mentioned Oak, Sexton and Rock hills. Most of these have persisted because they are more or less protected by a somewhat indurated phase of the sand and gravel beds which are general in their distribution over this area. The belt of country known as Holmes Valley near Vernon in Washington County, as has previously been noted by the writers, is a belt of country transitional from the low lands to the plateau. A similar transitional belt lying immediately west of the Choctawhatchee River is known as Euchee valley.*

SUMMARY.

The data that has been presented has shown that Eocene and Oligocene limestones project into Florida in a general northeast-southwest direction through the central part of this area. The southernmost exposures of these limestones are not on the streams at either the east or the west sides of the area, but on the somewhat higher lands near the central part. This fact indicates that contour lines on the top surface of the Eocene may be expected to curve farthest to the south near or somewhat west of the central part of this area. The line of the southernmost exposure of the Eocene-Lower Oligocene limestones as indicated on the sketch map, page 80, is believed to approximate rather closely to the location of the 50-foot contour on the top surface of these limestones. From the structurally high land the slope or dip in the formations is perhaps strongest to the east or southeast, and less rapid to the west.

* Fla. Geol. Surv., 4th Ann. Rpt., p. 113, 1912.

The structure in this area is further demonstrated by its influence on the location and characteristics of the principal streams. The two large rivers of this part of the State pass at either side of this area, approximately paralleling the structural axis. Moreover, each stream receives its principal tributaries in Florida from this area. The stream at the east side, the Apalachicola River, is impinging strongly on its left or east bank and is gradually migrating down the dip. The Choctawhatchee at the west side in a less conspicuous manner is through the greater part of its course in Florida impinging on its right or west bank. The Apalachicola, however, is more distinctly at the side of the anticline than is the Choctawhatchee.

On the west side of the Apalachicola and on the east side of the Choctawhatchee is a belt of low lands, while on the opposite bank are high lands. These topographic features are due to the structural conditions and are evidence of them. Because of these structural and drainage features, the originally higher land of the north is now of lower elevation than that farther south.* However, structure in this belt is not pronounced, and it is not to be hastily concluded that these mild large structures are sufficient to lead to the expectation of deposits of oil and gas. Smaller sharp structural features such as would in the nature of the case afford more promising prospecting for these deposits, have not been detected in this area.

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* The possible relation of topographic development to structure in the area east of the Ocklocknee river is discussed in the 9th Ann. Report, pp. 130-132.

STRUCTURAL CONDITIONS BETWEEN THE CHOCTAWHATCHEE AND AUCILLA RIVERS IN FLORIDA.

The present paper on the geology between the Apalachicola and Choctawhatchee Rivers is the third of a series of brief papers on limited areas in Florida in which structural conditions have received special consideration. The whole contiguous area now covered by these reports includes the territory from the Choctawhatchee to the Aucilla Rivers in west or central west Florida. This area is of especial interest because within it is found the transition from the geologic areas of southern Alabama and Georgia to the somewhat distinct structural area of peninsular Florida.

CONTOURS ON THE CHATTAHOOCHEE FORMATION.

The sketch map, page 80, has been prepared to accompany a summary of the results obtained in the study of these three areas. The contours shown on the map, marked 0, 50 and 100, are placed as nearly as practicable on the top surface of the Chattahoochee formation. The small key map of figure 3 indicates the data with regard to elevations from which these contours were constructed. While all the levels are in a sense approximate, owing to the difficulty in many cases of exactly placing the top surface of this formation, some are purely inferred elevations, and these are indicated by the use of the "plus-minus" sign. The inferred levels are those in the areas where the formation is completely concealed by later deposits.

The interval between the fullers earth horizon and the apparent top of the Chattahoochee formation near River Junction is 66 feet. The fullers earth exposure, however, is about one mile southeast of the limestone exposure, hence, allowing for the dip, the actual interval is probably close to 70 feet. The inferred levels on the Chattahoochee Limestone are obtained, where that formation is entirely concealed, by deducting this interval, 70 feet, from the known level of the fullers earth horizon at that place.

When placed in accordance with these levels, the 100-foot contour is observed to pass from the Apalachicola River somewhat south of River Junction in a northeast direction, crossing Little River near Attapulgus. From here the contour presumably bends to the south, since it comes into Florida again in the northeast cor-

ner of Gadsden County and crosses the Ocklocknee River near Lake Iamonia. The 50-foot contour starting from the Apalachicola River near Rock Bluff passes more nearly to the east, crossing the Ocklocknee River below the Seaboard Air Line Railway crossing.

CONTOURS ON THE ALUM BLUFF FORMATION.

Contours on the fullers earth horizon of the Alum Bluff formation, if placed on the map in the same way by known and inferred levels, would indicate essentially the same structure as that shown by contours on the Chattahoochee formation. From the Apalachicola River the contours on the fullers earth horizon run to the northeast, the 200-foot contour passing out of the state and crossing the tributaries of Little River somewhat north of Attapulgus, the actual level of the fullers earth at Attapulgus being 173 feet. The 150-foot contour on this formation starting from near Rock Bluff passes northeast to Jamieson, near the State line. East of the Ocklocknee River and north of the Seaboard Air Line Railway in Leon County, the fullers earth horizon, if formerly present, has apparently been removed by erosion and disintegration. If the former place of this horizon should be inferred from known levels on the Chattahoochee formation, it would be assumed that its 200-foot contour re-enters Florida north of Lake Iamonia in Leon County, and that the 150-foot contour runs about as far south on the east side of the Ocklocknee River as the Georgia, Florida and Alabama Railway. The 100-foot contour on this horizon has not been located on the Apalachicola River except by inference. The fullers earth is not found at Alum Bluff, and if formerly present was removed by erosion previous to the deposition of the Choctawhatchee formation. The eroded top of the Alum Bluff formation there lies at an elevation of about 70 feet above sea, and the fullers earth stratum would be expected to lie in that section at between 100 and 120 feet above sea.

On the Ocklocknee River the 100-foot contour would cross somewhat south of Midway, where the actual level of the fullers earth horizon is 114 feet above sea. On this formation, as on the Chattahoochee formation, there is thus observed a flattening out and reduction in dip in passing to the south. Farther south the contours have possibly an east-west or north of west to south of east direction.

Contours on the Choctawhatchee formation from the Choctawhatchee River to the Ocklocknee River have the general direction of north of west to south of east. Thus the upper Miocene apparently does not conform in structure to the Alum Bluff formation. At Alum Bluff the Choctawhatchee marl rests on the eroded top of the Alum Bluff formation at an elevation that is below the inferred level of the fullers earth horizon at that place and within probably about 40 feet of the base of the Alum Bluff formation. On the Ocklocknee River, on the other hand, the Choctawhatchee formation lies immediately above the fullers earth horizon, probably as much as 70 feet or more above the base of the Alum Bluff formation. In other words, the Choctawhatchee formation approximately parallels the general course of the present gulf border, and in this area cuts the Alum Bluff formation at an angle resting at the Apalachicola River on an older part of that formation than on the Ocklocknee River. This lack of conformity in structure is indicated on the sketch map, figure 4, page 42.

Several interesting and important facts are brought out by this study. Certain structural features are indicated both by topography and stratigraphy. There is plainly a broad syncline or trough which centers between the Ocklocknee and Apalachicola Rivers. To the east of the Ocklocknee River the formations which enter into the formation of this syncline rise slightly and continue to the east and south-east with but slight dip. At the west side of the syncline the formations rise to the structurally high area west of the Apalachicola River. The formations which enter into the structure of this syncline are the Alum Bluff Miocene, the Chattahoochee Oligocene and presumably the older Oligocene and Eocene formation which, however, are concealed except to the west. To the south and south-west the syncline gradually flattens out and disappears probably before reaching the present coast line.

The upper Miocene deposits, Choctawhatchee formation, which rest upon the eroded top surface of the Alum Bluff formation, so far as observed have no part in the formation of this syncline. From this it is inferred that the earth movements which formed this syncline took place following the close of the deposition of the Alum Bluff formation, and previous to the deposition of the Choctawhatchee formation.

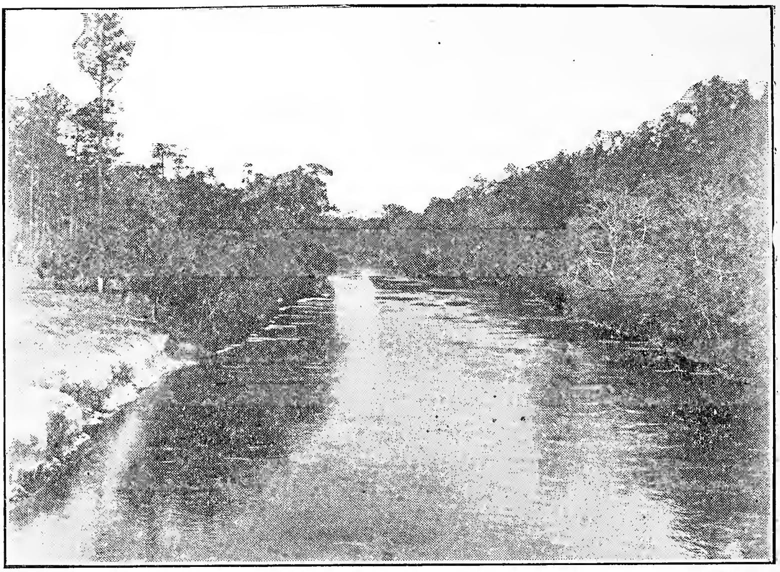

Fig. 7. View on the Chipola River.

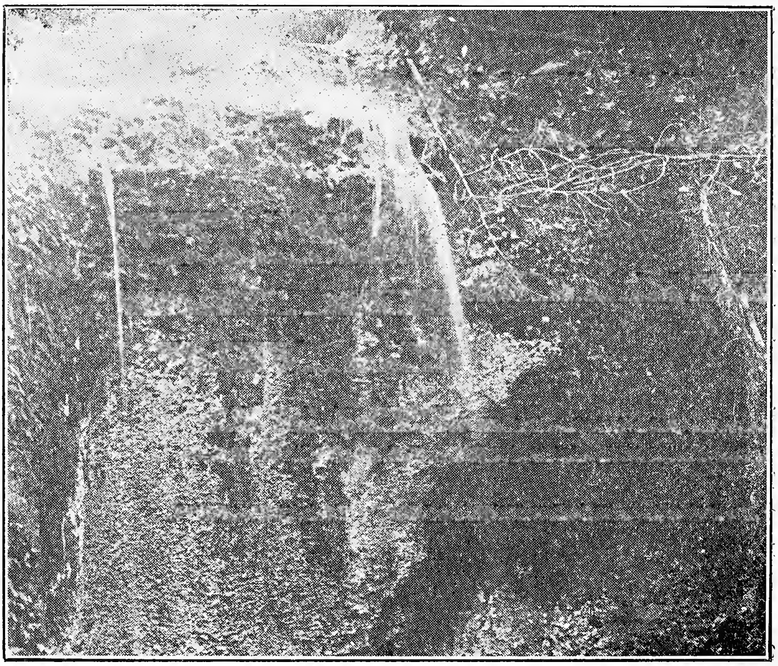

Fig. 8. Sink south of Chipley.

STATISTICS ON MINERAL PRODUCTION IN FLORIDA DURING 1917.

COLLECTED IN CO-OPERATION BETWEEN FLORIDA STATE GEOLOGICAL SURVEY AND U. S. GEOLOGICAL SURVEY.

The value of minerals produced in Florida during 1917 is considerably in excess of that of the preceding year. The total mineral production during 1916 is valued at $5,859,821, while that for 1917 is valued at $7,534,834.

BALL CLAY OR PLASTIC KAOLIN.

Three plants were engaged in mining ball clay in Florida during 1917. These were the Edgar Plastic Kaolin Company, Edgar; the Florida China Clay Corporation, Okahumpka; and the Lake County Clay Company, Okahumpka. The ball clays of Florida are white burning, refractory clays notable for their plasticity. They occur in association with sand from which they are separated by washing. The value of the ball clay produced, although not separately given, is included in the total mineral production of the State.

BRICK AND TILE.

The total number of common brick manufactured in Florida during 1917 was 28,457,000. In addition to building brick there was produced also drain-tile and fire-proofing brick. The total value of brick and tile products for the year 1917 was $224,606.

The following firms in Florida reported the production of brick during 1917:

Barrineau Brothers, Quintette.
Campville Brick Company, Campville.
Clay County Steam Brick Company, Green Cove Springs.
Dolores Brick Company, Molino.
Florida Industrial School for Boys, Marianna.
Gamble & Stockton Company, 108 W. Bay St., Jacksonville.
Glendale Brick Works, Glendale.
G. C. & G. H. Guilford, Blountstown.

Hall & McCormac, Chipley.
Keystone Brick Company, Whitney.
Lee Miller, Whitney.
Ocklocknee Brick Company, Ocklocknee.
Platt Brothers, South Jacksonville.
Tallahassee Pressed Brick Company, Havana.
Wilson-Owens Brick Company, Callahan.

FULLERS EARTH.

Florida is the chief producer of fullers earth in the United States, more than 75% of the total production during 1917 being credited to that State. The production in Florida, although not separately listed, is included in making up the total mineral production of the State. The fullers earth of Florida is used chiefly in clarifying mineral oils, although some is being prepared also for vegetable oils.

The following companies are engaged in mining fullers earth in Florida: The Atlantic Refining Company, Ellenton; The Floridin Company, Quincy and Jamieson; The Fullers Earth Company, Midway, and the Manatee Fullers Earth Corporation, Ellenton.

ILMENITE.

The production of ilmenite from the beach sands at Pablo Beach which was begun in 1916 was continued during 1917. During the year the plant was somewhat enlarged and was connected with the Florida East Coast railway by a side track. With the ilmenite is associated, aside from quartz sand, a considerable number of other minerals.* The company operating at this place is Buckman & Pritchard, Pablo Beach.

PEAT.

Peat is being produced in Beswick, Florida, by the Robert Ranson Company. This being the only plant in operation in the State, the production is not separately listed. The peat produced by this company is placed on the market in the form of prepared humus and peat litter.

* A Florida Rare-Mineral Deposit, by Donald M. Liddell, Eng. and Min. Jour., Vol. 104, No. 4, July 28, 1917.

PHOSPHATE.

The following statement on the production of phosphate in Florida was issued by the State Geological Survey in May, 1918, as Press Bull, No. 8.*

"The phosphate industry of Florida has now in volume of output almost regained its pre-war condition. This fact is brought out by co-operative statistics on production gathered by the Federal and State geological surveys. At the present time the shipments of phosphate are very largely for domestic consumption, the export business having been almost wholly cut off. However, the domestic shipments for 1917 lack only about a half million tons of equaling the maximum combined domestic and export shipments for any year previous to the war. The record shipment of phosphate in Florida is for 1913, the year immediately preceding the war, and amounts to 2,545,276 tons. This amount represents the combined domestic and export shipments, more than one-half being exported. During 1917 the shipments, which were almost entirley domestic, amounted to 2,022,599 tons or to within approximately a half million tons of maximum pre-war shipments.

"The extent to which the war has affected the phosphate industry may be realized from the following figures on shipment of phosphate rock from Florida: 1913, total shipments 2,545,276 tons; 1914, 2,138,891 tons; 1915, 1,358,611 tons; 1916, 1,515,845 tons; 1917, 2,022,599 tons. It is thus seen that shipments of phosphate fell to a minimum during 1915. In 1916 there was an appreciable increase, and in 1917 a very decided increase.

"The recovery of the industry has been due to increased output in the pebble phosphate fields together with a small production of soft phosphate. Total shipments of pebble phosphate in 1913 were 2,055,842 tons; 1914, 1,829,202 tons; 1915, 1,308,481 tons; 1916, 1,468,758 tons; 1917, 2,003,991 tons. The pebble industry therefore lacks but little having regained maximum production.

"The shipments of hard rock phosphate necessarily continue at

* The Phosphate Industry of Florida During 1917, by E. H. Sellards, Fla. Geol. Surv., Press Bull., No. 8.

low ebb, since the export business is cut off and the hard rock is used only to a limited extent in the domestic trade. During 1917 soft phosphate rock entered to some extent into the phosphate production, the total combined shipments of hard rock and soft phosphate being 18,608 tons.

"The value of phosphate shipped from Florida during 1917 is estimated as $5,464,493, while that shipped during 1916 was valued at $4,170,165. The production of phosphate rock in Florida since the beginning of the industry in 1888 to the close of 1917 is estimated by the Florida Geological Survey to be 33,143,084 tons, The value of the phosphate rock produced in Florida since 1888, according to statistics collected by the United States Geological Survey, is $122,966,681."

SUMMARY OF SHIPMENT OF PHOSPHATE IN FLORIDA FROM 1913 TO 1917, INCLUSIVE.

	1913.	1914.	1915.	1916.	1917.
Pebble Rock—					
Exported ----------	887,398	625,821	185,846	172,427	138,010
Domestic ----------	1,168,084	1,203,381	1,122,635	1,296,331	1,865,981
Total shipment -----	2,055,482	1,829,202	1,308,481	1,468,758	2,003,991
Hard Rock—					
Exported ----------	476,898	303,172	43,314	28,045	12,403
Domestic ----------	12,896	6,517	6,816	19,042	6,205
Total shipment -----	489,794	309,689	50,130	47,087	* 18,608
Pebble and Hard Rock Combined—					
Exported ----------	1,364,296	928,993	229,160	200,472	150,413
Domestic ----------	1,180,980	1,209,898	1,129,451	1,315,373	1,872,186
Total shipment -----	2,545,276	2,138,891	1,358,611	1,515,845	2,022,599
Total shipments from beginning of mining in 1888 to 1917, inc.---------					33,143,048

LIST OF MINING COMPANIES OF FLORIDA.

Acme Phosphate Company -----------Morriston, Fla.
Alachua Phosphate Company --------
American Agricultural Chemical Co.---2 Rector St., New York, N. Y., and Pierce, Fla.
American Cyanamid Co. --------------200 Fifth Ave., New York, N. Y., and Chicora, Fla.

* Includes soft rock phosphate.

Armour Fertilizer Works	Union Stock Yards, Chicago, Ill., and Bartow, Fla.
P. Bassett	Newberry, Fla.
Peter B. and Robert S. Bradley	92 State St., Boston, Mass., and Floral City, Fla.
J. Buttgenbach & Company	Holder, Fla.
C. & J. Camp	Ocala, Fla.
Charleston, S. C., Mining and Manufacturing Co.	Richmond, Va., and Ft. Meade, Fla.
Coronet Phosphat Co.	99 John St., New York, N. Y., and Plant City, Fla.
Cummer Lumber Co.	Jacksonville and Newberry, Fla.
Dunnellon Phosphate Company	Rockwell, Fla.
Export Phosphate Company	87 Milk St., Boston, Mass., and Mulberry, Fla.
Florida Phosphate Mining Corporation	Dickson Bldg., Norfolk, Va., and Bartow, Fla.
Florida Soft Phosphate and Lime Co.	Ocala, Fla.
Franklin Phosphate Co.	Newberry, Fla.
Holder Phosphate Co.	220 W. Ninth St., Cincinnati, O., and Inverness, Fla.
International Agricultural Corporation	
International Phosphate Co.	27 State St., Boston, Mass., and Ft. Meade, Fla.
Lakeland Phosphate Co.	Lakeland, Fla.
Mutual Mining Co.	Savannah, Ga., and Floral City, Fla.
Palmetto Phosphate Co.	812 Keyser Bldg., Baltimore, Md., and Tiger Bay, Fla.
Phosphate Mining Co.	55 John St., New York, N. Y., and Nichols, Fla.
Seminole Phosphate Co.	Croom, Fla.
Schilman and Bene	Ocala, Fla.
Societe Franco-Americaine des Phosphate de Medulla	Christina, Fla.
Societe Universalle De Mines, Industrie, Commerce et Agriculture	Pembroke, Fla.
Southern Phosphate Development Co.	Inverness, Fla.
Swift & Company	Union Stock Yards, Chicago, Ill., and Bartow, Fla.
T. A. Thompson	Ft. White, Fla.

SAND AND GRAVEL.

The sand produced in Florida is used chiefly for building, paving and road making and for cutting, grinding and blast purposes. The gravel produced is used principally for road material

and for railroad ballast. A limited amount is also used for roofing purposes. The total production of sand and gravel for 1917 was 262,971 tons, valued at $145,579.

The companies reporting the production of sand and gravel in Florida during 1917 are the following:

Atlantic Coast Line Railroad Company.
Akerman and Ellis, Lake Weir.
Interlachen Gravel Company, Interlachen.
Stone Products Company, Bartow.
Tampa Sand and Shell Company, Tampa.
A. T. Thomas Company, Ocala.

SAND-LIME BRICK.

The materials used in the manufacture of sand-lime brick are sand and lime. The bonding power of the brick is due to the chemical reaction between these ingredients. The chemical changes occur in the presence of heat, pressure and moisture and result in the formation of hydro-silicates of calcium and magnesium.

The sand used in the manufacture of sand-lime brick should be comparatively pure and preferably with some variation in the size of the grains. The mixture of lime, sand and water, is cut in the form of bricks and conveyed to a hardening cylinder. Necessary heat and pressure are obtained in the hardening cylinder adapted for the purpose. The sand-lime bricks are placed in this cylinder and subjected to a pressure and temperature which vary according to the method of treatment.

Two companies were actively engaged in the manufacture of sand-lime brick in Florida during 1917 as follows:

The Bond Sandstone Brick Company, Lake Helen.
The Plant City Composite Brick Company, Plant City.

The production of sand-lime brick in Florida during 1917, although not separately listed, is included in making up the total mineral production of the State.

LIME AND LIMESTONE.

The total quantity of quick and hydrated lime made in Florida during 1917 amounted to 12,320 tons, valued at $72,580. The lime produced in Florida is chiefly quick lime, the production of hydrated lime in 1917 being about one-fourth that of quick lime.

The total amount of limestone produced in Florida for all purposes except that of burning for quick lime including building, road making, railroad ballast and agricultural limestone, and including flint rock associated with the limestone, is valued at $634,602. The following companies in Florida have reported the production of lime, limestone or flint for the year 1917:

Florida Lime Company, Ocala.
Commercial Lime Company, Ocala.
Standard Lime Company, Kendrick.
Blowers Lime and Phosphate Company, Ocala.
Brooksville Lime, Fertilizer and Crushed Rock Company, Brooksville.
Crystal River Rock Company, Crystal River.
Live Oak Limestone Company, Live Oak.
Florida Crushed Rock Company, Montbrook.
E. P. Maule, Ojus.
Pineola Lime Company, Pineola.
Atlantic Coast Line Railroad Company.
A. T. Thomas and Company, Ocala.
Fred T. Ley and Company.

WATER.

The total sales of mineral and spring water in Florida during 1917, as shown by the returns from the owners of springs and wells, amounted to 142,030 gallons, valued at $9,850.

The companies reporting the production of water for commercial purposes during 1917 include the following:

Espiritu Santo Springs Company, Espiritu Santo Springs, Safety Harbor, Florida.

Good Hope Water Company, Good Hope Mineral Water Well, Jacksonville, Florida.

Hampton Springs Water Company, Hampton Springs, Hampton Springs, Florida.

Magnesia Springs Water Company, Magnesia Spring, Grove Park, Florida.

Purity Spring Water Company, Purity Spring, Tampa, Florida.

Green Cove Springs Improvement Company, Quisisana Spring, Green Cove Springs, Florida.

E. C. Harington, Wekiva Springs, Apopka, Florida.

SUMMARY STATEMENT OF MINERAL PRODUCTION IN FLORIDA DURING 1917.

Common or building brick, fire-proofing brick and drain tile	$ 224,606
Lime and limestone, including lime and ground limestone for agricultural use, and crushed rock for railroad ballast, concrete and road material	707,182
Mineral waters	9,850
Phosphate rock	5,464,493
Sand and gravel	145,579
Mineral products not separately listed, including ball clay, fuller's earth, pottery products, abrasive material, mineral dust, and sand-lime brick	983,124
Total mineral production during 1917 valued at	$7,534,834

MOLLUSCAN FAUNA FROM THE CALCAREOUS MARLS IN THE VICINITY OF DE LAND, VOLUSIA CO., FLORIDA.

BY WENDELL C. MANSFIELD.

At the time of the preparation of the paper by Messrs. G. C Matson and F. G. Clapp, entitled "A preliminary report on the geology of Florida, with special reference to the stratigraphy,"* it was recognized that knowledge of the paleontologic content of the calcareous marls occurring in the vicinity of DeLand, Fla., was inadequate for accurately determining the geologic age of the beds. Therefore Dr. E. H. Sellards, State Geologist of Florida, at the request of Dr. T. Wayland Vaughan, made a careful collection in 1908 at the marl pit about one mile south of the city, and has furnished a detailed description of the exposure. The present report is based principally on the material obtained by Dr. Sellards, as the previous collections were procured mostly from well-borings, and is here published by permission of the Director of the U. S. Geological Survey.

Citations in literature to the fauna and geologic horizons at DeLand are few. The following are noted: "The Nashua marl is thought to rest unconformably upon the Miocene at DeLand; but this opinion lacks confirmation, as the collections from that locality have not been studied in sufficient detail to determine the exact age of the beds."†

Log of the City Well at DeLand.‡

Material	Thickness, feet	Depth, feet
"Sand, white	12	12
Clay, yellow, sandy	10	22

* Prepared in co-operation with the U. S. Geological Survey and the Florida State Geological Survey, under the direction of T. W. Vaughan; Florida Geol. Surv., 2nd Ann. Report, pp. 21-173, 1909.

†Matson, G. C., and Clapp, F. G., 2nd Ann. Report, Fla. Geol. Surv., 1909, p. 128.

‡Matson, G. C., U. S. G. S. Water Supply Paper No. 319, pp. 417-418, 1913.

At the time this paper was printed, the author was engaged in field work and did not have the opportunity of reading the proof. (Ed.)

Shell marl	14	36
Shell marl and sand	18	54
Limestone, soft, cream-colored, with shell fragments	36	90
Limestone, gray	20	110
Limestone, hard, gray and cream-colored	60	170
Limestone, hard, light brown	39	209
Limestone, hard, white to brown	21	230
Limestone, hard, white to brown, porous	20	250
Limestone, soft, white, fossiliferous	14	264

"From the samples obtained between 22 and 54 feet, Vaughan identified Pliocene fossils. In the sample obtained between 54 and 70 feet, he identified Miocene shells. This indicates that both the Nashua and Choctawhatchee marls are present at DeLand, and gives some idea of their minimum thickness at that locality."

"Samples of marl from a well at DeLand were found by Vaughan to contain: *Pecten* (type of *madisonius*) and *Chione* (type of *cancellata*). From the presence of the madisonius type of Pecten, the marl is believed to be Miocene."*

Following is a section at the marl pit owned by the city of DeLand, about one mile south of the city, made December 7, 1908, supplemented by a section made March 4, 1915, by Dr. E. H. Sellards, who kindly furnished them for this publication:

5. Light colored incoherent sand	4 to 10 feet
4. Sandy clay, yellow, drab and blue, in places containing oyster shell marl	6 to 10 feet
3. Shell marl, very irregular top surface	2 to 4 feet
2. Clay stratum with concretions	2 to 6 inches
1. Shell marl with slightly irregular top surface	3½ to 4 feet

Dr. Sellards also furnished the following notes on the section:

"The shell marl, No. 1 of this section, has a slightly irregular or undulating top surface, the variation in level amounting to as much as 6 inches vertical in 6 feet horizontal, possibly more in places. The change from the shell marl to the clay stratum above is abrupt, and the largest concretions in the clay are found just above the marl. The clay stratum in turn passes gradually into the overlying shell marl."

"This shell marl, No. 3 of the section, has an extremely irregular

* Matson and Sanford, Water Supply Paper No. 319, p. 133, 1913.

top surface, and the most pronounced break in the section is that between this marl and the overlying sandy clay."

"Stratum No. 4 of the section is lacking in constancy. In places it is chiefly clay, although elsewhere it becomes quite sandy. At the time the first section was made in this pit no fossils were found at this level, although in March, 1915, the stratum as then exposed was found to contain in places oyster shell marl.

"The collections made in 1908 were from the shell marl, No. 1, and from the marl No. 3. A feature of some interest in these pits is the existence of sinkholes encountered in mining, of which there is no indication at the surface. One of these at the north side of the pit is 6 or 7 feet in diameter and breaks through both marl strata, its depth being unknown."

The following list gives the fauna from the upper (No. 3 of section) and lower (No. 1 of section) beds at the marl pit about one mile south of DeLand, Volusia county, Florida, with the geologic range of species and their occurrence in the Waccamaw and Caloosahatchee marls:

U—upper bed; L—lower bed; M—Miocene; P—Pliocene; Pl.—Pleistocene; R—Recent; W—Waccamaw marl; C—Caloosahatchee marl.

Gastropoda	U	L	M	P	Pl	R	W	C
Actaeon punctostriatus Adams	x		x	x	x	x	.	x
Anachis obesa C. B. Adams, var. ?	x	x		x	x	x	x	
Bulla ? (frag.)	x							
Conomitra (yo.)	x							
Crepidula aculeata var. costata Morton	x		x	x	x	x	x	x
Crepidula convexa Say	x			x	x	x	x	x
Crepidula cf. convexa Say		x						
Crepidula fornicata Say	x		x	x	x	x	x	x
Crepidula fornicata Say, cf. var. rostrata Conrad	x							
Crucibulum sp. (yo.)	x							
Drillia tuberculata Emmons	x		x	x			x	?
Drillia cf. tuberculata Emmons	x							
Epitonium sp. A, aff. Krebsii Moerch	x							
Epitonium sp. B, aff. lineata Say	x							
Epitonium delandense n. sp. Mansfield	x							
Fasciolaria apicina Dall	x			x			x	x
Fissuridea carolinensis Conrad	x		x	x			?	x
Busycon perversum Linnacus	x		x	x	x	x	x	x
Mangilia cerina Kurtz & Stimpson	x			x	x	x	x	x
Marginella near bella Conrad	x							

Gastropoda	U	L	M	P	Pl	R	W	C
Marginella bella Conrad	x		x	x	x	x	x	x
Marginella limatula Conrad	x		x	x	x	x	x	x
Marginella cf. limatula Conrad		x						
Melanella sp.	x							
Natica cf. pusilla Say	x							
Polynices (Neverita) duplicatus Say	x		x	x	x	x	x	x
Polynices cf. duplicatus Say		x						
Odostomia (Chrysallida) sp. A.	x						?	?
Odostomia sp. (worn) sp. B.	x							
Oliva literata Lamarck	x	x	x	x	x	x	x	x
Olivella nitidula Dillwyn	x	x	x	x	x	x	x	x
Seilia Adamsii H. C. Lea	x		x	x	x	x	x	x
Sinum perspectivum Say	x				x	x		
Simnia uniplicata Sowerby	x					x		
Terebra concava Say	x		x	x	x	x	x	x
Terebra dislocata Say	x		x	x	x	x	x	x
Terebra (yo.)	x							
Turbonilla (Chemnitzia) sp. A		x		x			x	x
Turbonilla (Pyrgiscus) sp. B	x			?			?	
Urosalpinx sp.	x							
Pelecypoda								
Abra aequalis Say	x	x	x	x	x	x	x	x
Anomia simplex d'Orbigny	x		x	x	x	x	x	x
Arca (Noetia) limula Conrad	x		x	x			x	x
Arca cf. plicatura Conrad	x							
Arca transversa Say	x	x		x	x	?	x	?
Arca cf. transversa Say	x							
Cardita sp (yo.)	x							
Cardium oedalium Dall	x			x			x	x
Chione cribraria Say ?	x							
Chione latilirata Conrad	x		x	x	x	x	x	x
Corbula inæqualis Say, var. A.	x	x	x	?				
Corbula inæqualis Say, var. B.	x	x	x	x			x	
Crassatellites speciosa A. Adams	x		x	x	x	x	x	x
Crassinella lunulata Conrad	x	x	x	x	x	x	x	x
Diplodonta acclinis Conrad	x		x	x			x	x
Divaricella quadrisulcata d'Orbigny	x		x	x	x	x	x	
Donax variabilis Say ?	x							
Dosinia (yo.)	x	x						
Dosinia (fragments)		x						
Garrarium metastriatum Conrad	x		x	x			x	x
Gemma trigonia Dall, n. sub. sp. delandensis Mansfield	x	x	?	?	?		?	?
Glycymerus (yo.)		x						
Leda acuta Conrad, variety ?	x	x	x	x	x	x	x	x
Mulinia lateralis Say var. A	x	x	?	?			?	?
Mulinia lateralis Say var. B	x	x	?	?			?	?

Pelecypoda	U	L	M	P	Pl	R	W	C
Mulinia contracta Conrad	x	x	?	?			?	?
Nucula proxima var. trunculus Dall	x	x	x	x	x		x	x
Ostrea sculpturata Conrad	x		x	x			x	x
Ostrea virginica Gmelin	x		?	x	x	x	x	x
Ostrea (yo.)		x						
Pecten eboreus var. solaroides Heilp	x		?	x				x
Pecten eboreus Conrad ?	x							
Pecten (yo.)	x	x						
Phacoides multilineatus Tuomey & Holmes	x	x	x	x	x	x	x	x
Phacoides radians Conrad var. ?	x		x	x	x	x	x	x
Phacoides waccamawensis Dall, n. subsp. delandensis Mansfield	x	x	?	?				
Plicatula sp. (yo.)	x							
Tellina (Angulus) declivis Conrad	x		x	x	x			x
Transennella near Stimpsoni Dall	x							
Venericardia perplana Conrad	x		x	x	x	x	x	x
V. perplana cf. var. abbreviata Conrad		x						
Venericardia tridentata Say	x	x	x	x	x	x	x	x
Venericardia sp. (eroded)		x						
Venericardia sp. (yo.)		x						
Venus rileyi Conrad	x		x	x	?		x	x
Venus sp. (frag.)	x							
Miscellaneous								
Balanus sp.	x	x						
Crab chela		x						
Echinid spines	x	x						
Membranipora cf. lacroixii (1.)	x							
Myliobatis sp. (2.)	x		x	x				
Septastrea crassa Holmes (3.)	x		x	x			x	x
	79	34	36	44	31	29	39	38

(1.) Determined by Dr. R. S. Bassler.

(2.) Determined by Dr. J. W. Gidley, with age probably Miocene.

(3.) Determined by Dr. T. W. Vaughan, with age upper Miocene or Pliocene.

COMPARISON OF THE FAUNA IN THE UPPER AND LOWER MARL BEDS.

The forms in the lower bed are more weathered and poorly preserved than in the upper.

Fifteen identified species, including varieties, are common to both. *Divaricella quadrisulcata* d'Orbigny, an unreported Florida Pliocene species, is found only in the upper bed. As there appear to be no varietal distinctions in the species of the two beds, no geo-

logical time discrimination can be made, except in the time sequence of deposit.

In addition to the above collections, there are in the U. S. National Museum the following forms:

From Wells at DeLand Landing.

Arca plicatura Conrad—depth not given.

Arca limula Conrad—depth not given.

Scapharca (*Scapharca*) identified as *transversa* Say, labelled Pliocene in age. Depth not indicated.

Phacoides waccamawensis Dall, var. ?—depth not given.

From Well in DeLand.

Mulinia identified as *congesta* Conrad, labelled Miocene in age. Taken at a depth of 30 feet below the surface.

Oliva literata Say. Taken at a depth of 36 to 54 feet.

From DeLand.

Mulinia identified as *congesta,* var. *contracta* Conr.; labelled Miocene in age.

Discussion of the fauna in the upper and lower beds at the marl pit about one mile south of DeLand, Fla.

Number of species of mollusks considered in time range ---------------- 45
Percentage of species with varieties considered in time range, that are believed to continue to the Recent ---------------- 64+
Number of species with varieties considered in time range, exclusively Miocene ---------------- (?1)
Number of species with varieties considered in time range, reported not lower than the Pliocene (including the Carolinas) ---------------- 8
Number of species with varieties, considered in time range, not younger than the Pliocene (including the Carolinas) ---------------- 11
Percentage of species with varieties, considered in time range, in the Florida Pliocene ---------------- 82+
Percentage of species with varieties, considered in time range, in the Waccamaw marl of the Carolinas ---------------- 84+

The following species at DeLand appear to be lacking in the Caloosahatchee Pliocene; those preceded by query are questionably found:

Anachis obesa var. ? C. B. Adams.
? *Drillia tuberculata* Emmons.
Epitonium aff. *krebsii* Moerch.
Epitonium aff. *lineata* Say.
Epitonium delandense n. sp.
? *Odostomia* (*chrysallida*) sp. A.
Sinum perspectivum Say.
Simnia uniplicata Sowerby.
? *Arca transversa* Say (lighter shell).
Corbula inaequalis Say, vars. A. and B.
Divaricella quadrisulcata d'Orbigny.
? *Mulinia lateralis* Say. Varieties.
Mulinia contracta Conrad.
Phacoides waccamawensis Dall, new subsp. *delandensis.*

The following species appear to be lacking in the Waccamaw Pliocene in South Carolina; those preceded by a query are questionably found.

Actaeon punctostriatus Adams.
Epitonium aff. *lineata* Say.
Epitonium aff. *krebsii* Moerch.
Epitonium n. sp. *delandense.*
? *Fissuridea carolinensis* Conr.
? *Gemma trigonia* Dall, n. subsp. *delandensis.*
? *Odostomia* sp. A.
Sinum perspectivum Say.
Simnia uniplicata Sowerby.
? *Turbonilla* (*Pyrgiscus*) sp. B.
Corbula inaequalis Say, var. A.
Pecten eboreus, var. *solaroides* Heilprin.
Phacoides waccamawensis, subsp. *delandensis.*
Tellina declivis Conrad.
? *Mulinia lateralis* Say, vars.
?*Mulinia contracta* Conrad.

The following species, one mile south of DeLand, are not reported lower than the Pliocene of Florida.

Fasciolaria apicina Dall.
Sinum perspectivum Say. Reported not earlier than the ~~Pliocene.~~ Pleistocene
Cardium oedalium Dall.
Phacoides multilineatus Tuomey and Holmes—found in the Miocene at Mayesville, S. C.
Simnia uniplicata Sowerby. Not heretofore reported fossil.
Arca transversa Say.

In regard to other forms from one mile south of DeLand the following may be said:

Phacoides waccamawensis Dall, new subsp. *delandensis.* The size of the shells compares with *P. tuomeyi Dall,* and the sculpture with *waccamawensis* Dall. The latter species is not reported lower than the Pliocene in Florida.

Divaricella quadrisulcata d'Orbigny. This species has been reported from the Pliocene of the Carolinas, but not from the Florida Pliocene.

Corbula inaequalis Say, var. A. The DeLand forms are more characteristic of the known Miocene of the Carolinas. A similar form is found at Orange City, Fla.

Corbula inaequalis Say, var. B. The DeLand forms are closely related to those at Wilmington and Cronly, N. C.; and at Orange City, Fla.

Arca transversa Say. DeLand forms have much lighter shells and lower beaks than those of the Caloosahatchee Pliocene, and are closely related to the forms at Cronly and Neill's Eddy Landing, N. C.; and are similar to the Pleistocene forms found at Simmons Bluff, S. C.

Mulinia lateralis vars. A. and B. and *contracta* Conrad from DeLand are probably varieties of the same species as the forms grade into each other. The shape of the shells somewhat resembles *congesta* Conrad, and might be so identified by some authors, but owing to the lightness of the shell and the weak hinge articulation, they appear nearer *lateralis* than *congesta.*

Similar forms are found ½ mile south of DeLeon Springs and near Orange City, Fla.

The Caloosahatchee Pliocene forms are somewhat lighter and have a more distinct carinated dorsal posterior ridge and more truncated edges.

A report of the stratigraphic section and of a small fossil collection, which was identified by Dr. Vaughan, made at Orange City, Fla., about five miles south of DeLand marl pit, is as follows:*

"One-fourth mile south of the railroad station at Orange City there is an exposure of marl which is doubtfully referred to the Pleistocene, though further collections may show it to be Pliocene.

The section at this locality has a thickness of about 18 feet, but only the lower part is fossiliferous.

Unassorted white sand	3 feet
Stratified hard white sandy clay	3 feet
Well stratified ferruginous sand and clay	5 feet
Yellow to white marl, very fossiliferous	7 feet
Total	18 feet

* Matson, G. C., and Clapp, F. G., Second Annual Report, Fla. Geol. Surv., 1909, p. 149.

The basal member of this section furnished the fossils listed below:

Melampus lineatus Say.
Terebra concava Say.
Olivella mutica Say.
Oliva literata Lam.
Fulgur pyriformis Conrad.
Littorina irrorata Say.
Leda acuta Conrad.
Arca transversa Say."

A later small collection about ¼ mile north of the railroad at Orange City was not reported in the Second Annual Report of the Florida Geol. Survey.

A comparison of the faunas obtained respectively ¼ mile north and south of Orange City with that near DeLand, listed in this paper, shows a very close relationship and probably represents nearly if not quite the same geological horizon. Of twenty forms collected near Orange City, fifteen are also found at DeLand.

The following species, identified by Dr. T. W. Vaughan, were found eleven to seventeen feet below the surface one-half mile (÷) south of DeLeon Springs Station, Fla.*

Marginella contracta Conrad.
Terebra dislocata Say.
Oliva literata Lam.
Melongena corona Gmel.
Crepidula aculeata Gmel.
Crepidula convexa Say.
Crepidula plana Say.
Cryptonatica pusilla Say.
Arca transversa Say.
Arca ponderosa Say.
Arca limula, var. *platyura* Dall.
Arca plicatura Say.
Pecten gibbus Linn.
Carditamera arata Conrad.
Venericardia tridentata Say.
Phacoides multilineatus T. and H.
Phacoides waccamensis Dall.
Phacoides radians Conrad.
Cardium robustum Solander.
Cardium isocardia Linn.
Venus campechiensis Gmel.
Chione cancellata Linn.
Mulinia lateralis Say.
Corbula inaequalis Say.

Geologic Horizon—"Pliocene (compare Dr. Dall's previous reference to Miocene at DeLeon Springs, Wag. Free Inst. Sci.)" (Vaughan).

About 53 per cent of the species in this and other collections from DeLeon Springs occur also at DeLand.

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* Matson, G. C., and Clapp, F. G., 2nd Ann. Rpt., Florida Geol. Surv., 1909, p. 132.

AGE OF THE FAUNA NEAR DELAND.

Chione cancellata Linnaeus is not present. It is a questionable Miocene species according to Doctor Dall. (Wagner Inst. Sci., vol. III, pt. 6, p. 1291). This species is also not represented in the collections from near Orange City, but it is represented in those from DeLeon Springs, Nashua, and at other localities along the St. Johns river.

The bulk of the fauna consists of *Mulinia lateralis* Say, vars., *Arca transversa* Say, *Ostrea sculpturata* Conrad, and *Corbula inaequalis* Say, vars. A. & B.

Of 58 forms from DeLand, approximately 70% (including varieties) are present also in both the Caloosahatchee and Waccamaw Pliocene, but only about 48% are found in the Duplin Miocene at Mayesville, S. C. Moreover, there have been certain species cited that have not been reported from Florida lower than the Pliocene.

On the other hand, certain species above cited are either not represented or sparsely so in the Pliocene of Florida. Some of these, however, have been reported from the Pliocene of the Carolinas, suggesting a close relationship.

The beds at DeLand appear to be of the same geologic horizon as those near Orange City, and about the same as that ½ mi. south of DeLeon Springs, whose fauna is listed in this report. Taking the fauna as a whole, it suggests a closer relationship to the Pliocene than to the known Upper Miocene.

DESCRIPTIONS OF ONE NEW SPECIES AND TWO NEW SUB-SPECIES.

EPITONIUM DELANDENSE MANSFIELD, NEW SPECIES.

Fig. 9, No. 1.

Shell elongate, slender, gradually tapering, with seven (excluding the lost nucleus) well rounded, close-set whorls; suture moderately deep and concealed; varices about ten in number, thin and slightly reflected on the earlier whorls, but heavier, completely reflected and rounded on the later whorls, the posterior ends of these varices on each whorl twist toward the following varices at the suture, and, as a rule, overlap those of the preceding; varices extend diagonally across the whorl, and when followed up the spire make

about a half turn around the axis; terminal varix heavier, roughened by a few parallel striæ and overlaps by a callous thickening the basal ends of five other varices beneath the lower axial margin of the aperture; spiral sculpture over about three-fourths of the anterior surface of the whorl consists of about ten slightly raised, rounded, equally spaced, moderately broad bands separated by narrow impressed lines, giving a pleated appearance to the shell.

The Type (Cat. No. 168212, U. S. N. M.) measures, length 13.2 mm, maximum diameter 5 mm.

This species is closely related to *Epitonium turricula* Say, but differs from this chiefly in having a coarser banded spiral sculpture.

Epitonium groenlandicum Chemnitz has a much heavier and coarser sculpture, both spiral and axial.

Type locality—Upper marl bed about one mile south of DeLand. Volusia County, Florida. Dr. E. H. Sellards, collector.

GEMMA TRIGONA DALL, NEW SUBSPECIES DELANDENSIS.

Fig. 9, Nos. 2-3.

The size of this form and the strength of the cardinal teeth are like the type of the species, *Gemma trigona* Dall; but it differs from the latter in having a rounder basal margin and a well defined concentric surface sculpture.

It is smaller than *Gemma magna* Dall, more equilateral, has larger and stronger cardinal teeth, and coarser concentric surface sculpture.

The type (Cat. No. 168211 U. S. N. M.) measures: right valve, length 4 mm.; height 3.7 mm.; diameter (double) 2.2 mm.

Type locality—Upper marl bed about one mile south of DeLand, Volusia County, Florida. Dr. E. H. Sellards, collector.

At localities ½ mile north and south of Orange City, Fla., there are forms with nearly smooth surface sculpture, but otherwise similar to those at DeLand; these, I believe, represent only local variations of the same subspecies.

PHACOIDES (BELLUCINA) WACCAMAWENSIS DALL, NEW SUBSPECIES DELANDENIS MANSFIELD.

Fig. 9, No. 4.

This is a larger form with more radial ribs than type, averaging about twelve. The anterior dorsal area is rougher, being marked

by a continuation of some of the concentric lamellae. The concentric lamellae are closer spaced and give a more even appearance to the shell sculpture.

In size the shell resembles *Phacoides tuomeyi* Dall, but it has more radial ribs and leaflike sculpture on the posterior dorsal area.

The type (Cat. No. 168212, U. S. N. M.) measures: right valve, length 9.0 mm., height 9.1 mm., diameter (double) 5.8 mm.

Type locality—Upper marl bed about one mile south of DeLand, Volusia County, Florida. Dr. E. H. Sellards, collector.

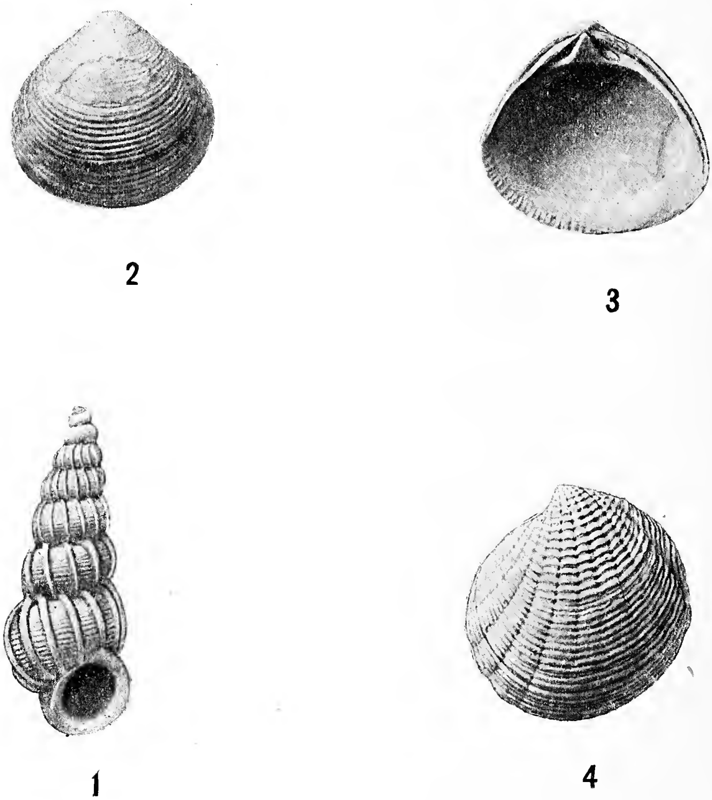

Fig. 9. New Pliocene Invertebrates. No. 1, Epitonium delandense n. sp.; No. 2-3, Gemma trigona Dall, new subspecies delandensis; No. 4, Phacoides (Bellucina) waccamawensis Dall, new subspecies delandensis.

ADDITIONAL COLLECTION FROM STRATUM NO. 4 OF THE SECTION.

After the completion of the foregoing paper, which considered only the fauna from strata Nos. 3 and 4 of the section at the city marl pit at DeLand made by Dr. E. H. Sellards and included in this report, the writer received from the Florida Geol. Survey a consignment of fossils collected by Mr. H. Gunter from stratum No. 4 of this same marl pit.

According to Dr. Sellards, the shell marl No. 3 of his section has an extremely irregular top surface, and the most pronounced break in the section is that between this marl and the overlying sandy clay (stratum No. 4.)

The fossil collection from stratum No. 4 is represented by only one species, *Ostrea virginica* Gmelin. From this one species, it is hardly possible to assign the age, but as *Ostrea sculpturata* Conrad is plentifully represented in the underlying fossiliferous stratum, it appears highly probable that this oyster bed should be assigned to the Pleistocene.

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